VOL. 107 • NO. 2779 • PAGES [illegible]

April 2 [illegible]

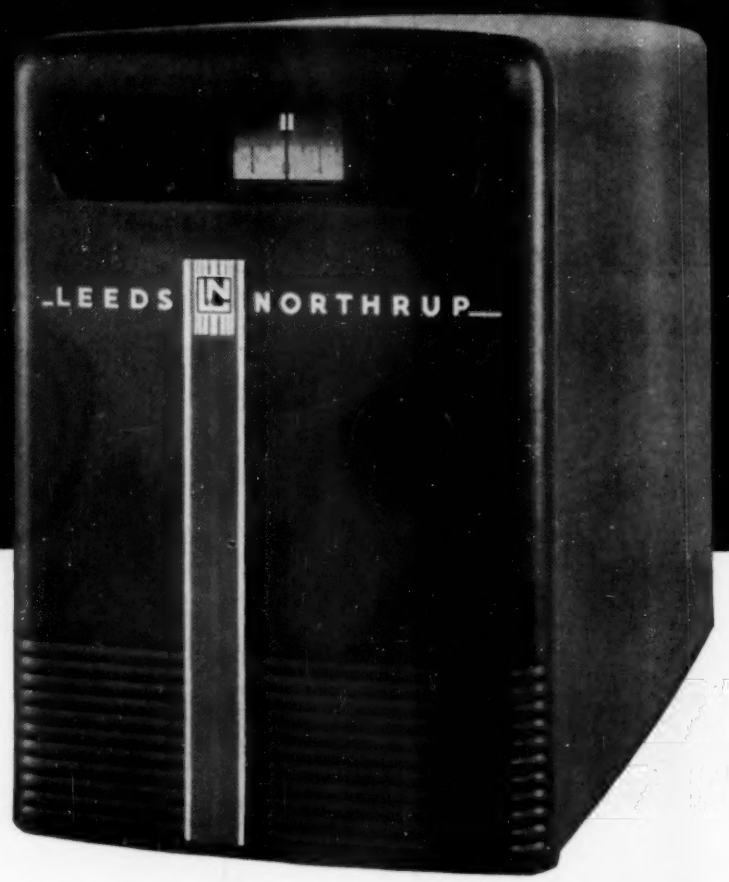
Science

Assembly of Synchrotron Condenser Unit

(See page 339)

NEW SERIES L&N GALVANOMETERS: COMPACT, SHORT PERIOD, GOOD SENSITIVITY

L & N Reflecting Galvanometer Type E



This new, completely different, Type E Galvanometer has its moving system, magnet, lamp, scale, and lamp transformer in a single, compact case. Just place the instrument on a bench or table, plug into a 115-volt, 60 or 50 cycle outlet, and it's ready to use.

Sensitivity is ample for many potentiometer and bridge circuits for which we formerly supplied remote-scale L&N galvanometers.

In addition to its normal sensitivity, this instrument also has, in effect, a low sensitivity, which is often a great help if a deflection shoots the galvanometer's indicating light-spot off scale. For, in that case, a secondary spot appears. Moving only one-tenth as far as the main spot, this secondary device shows both direction of deflection and approximate magnitude of the circuit-balancing adjustments required.

Zero is adjusted by turning a knob on the front of the instrument. Deflection of the full-sensitivity light spot is linear to within 1%. Sturdy metal case provides electrical shielding.

CHARACTERISTICS

List No.	Sensitivity per mm scale division	Nominal Period, Seconds	Nominal Resistance, Ohms	
			External Critical Damping	System
2430-a	0.5 microvolt	3	50	17
2430-c	0.005 microampere	2.5	400	25
2430-d	0.0005 microampere	3	25,000	550

For most applications, these Galvanometers can be used with circuits having external resistances which differ considerably from the above values. All three Galvanometers use the same magnet, and their moving systems are interchangeable. Thus, one complete instrument with two additional systems gives the same variety of characteristics as three complete galvanometers. For further details, write Leeds & Northrup Co., 4926 Stenton Ave., Phidalelphia 44, Pa.

LEEDS & NORTHRUP

MEASURING INSTRUMENTS · AUTOMATIC CONTROLS · TELEMETERS
HEAT-TREATING FURNACES

Jrl. Ad ED22(4)

The KINSEY REPORT on Sex Behavior

By ALFRED C. KINSEY, Professor of Zoology; WARDELL B. POMEROY, Research Associate, and CLYDE E. MARTIN, Research Associate, Indiana University. Based on surveys made by members of the staff of Indiana University and supported by the National Research Council with Rockefeller Foundation funds. 804 pages, with 173 Charts and 159 Tables. $6.50.

Sexual Behavior in the Human Male

OPINIONS

"Kinsey's notable research and its publication may well mark an epoch in the evolution of social attitudes."—*Jl. American Medical Association*

"The facts are now available and in so effectively presenting them the authors are due the gratitude of all intelligent peoples interested in the advancement of knowledge."—*Science*

"One of the finest examples of cooperation among the physical and social sciences known to date. Kinsey's encyclopedic work is being hailed as one of the great sociological labors of our age. . . . He deals with facts, not opinions or fantasies."—*Science Illustrated*

ALMOST overnight *The Kinsey Report* has become the standard reference on human male sex behavior. Many colleges have already required it for classes in sociology, abnormal psychology, marriage counselling and sex hygiene.

Educators generally acknowledge it to be the most important research done to date in its field, because, for the first time, it enables the problem to be considered on a truly factual and scientific basis. It is far-reaching and intensive in its examination of the differences in patterns of male sexual behavior according to social, economic and age levels and, as a result provides detailed data that find pertinent applications in the fields of biology, medicine, sociology, psychology, anatomy, and physiology. 57 pages of Clinical Tables are included to provide easily consulted recapitulations of all the findings of the study.

- - - - - - - - - - - - - - - - - *ORDER FORM* - - - - - - - - - - - - - - - - -

W. B. SAUNDERS COMPANY, West Washington Square, Phila. 5

Sc. 4-2-48

Please send

Kinsey, Pomeroy & Martin's Sexual Behavior in the Human Male $6.50

☐ Charge my account. ☐ Check enclosed.

NAME ..... ADDRESS .....

Science

Mildred Atwood, Acting Editor — Theo. J. Christensen, Business Manager

Publications Committee
Farrington Daniels, John E. Flynn, Kirtley F. Mather, Walter R. Miles, Malcolm H. Soule, Steven M. Spencer

Vol. 107 No. 2779 Friday, April 2, 1948

CONTENTS

(Cover photo by John F. Brock.)

Science, a weekly journal, is published each Friday by the American Association for the Advancement of Science at The Business Press, Incorporated, N. Queen St. and McGovern Ave., Lancaster, Pa. Founded in 1880, it has been since 1900 the official publication of the AAAS. Editorial and Advertising Offices, 1515 Massachusetts Avenue, N.W., Washington 5, D. C. Telephone, EXecutive 6060 or 6061. Cable address, SCIMAG, Washington, D. C. Entered as second-class matter at the Post Office at Lancaster, Pa., January 13, 1948, under the Act of March 3, 1879. Acceptance for mailing at the special rate postage provided for in the Act of February 28, 1925, embodied in paragraph 4, Sec. 538, P. L. and R., authorized January 13, 1948.

Articles offered for publication should be sent to the Editor. The AAAS assumes no responsibility for the opinions expressed by contributors. Membership correspondence for the AAAS should be sent to the Administrative Secretary.

Annual subscription, $7.50; single copies, $.25; foreign postage (outside the Pan-American Union), $1.00 extra; Canadian postage, $.50 extra. Remittances and orders for subscriptions and single copies should be sent to the Circulation Department, AAAS, North Queen Street and McGovern Avenue, Lancaster, Pennsylvania, and 1515 Massachusetts Avenue, N.W., Washington 5, D. C. Claims for missing numbers will not be allowed if received more than 60 days from date of issue. No claims allowed from subscribers in Central Europe, Asia, or the Pacific Islands other than Hawaii or because of failure to notify the Circulation Department of a change of address or because copy is missing from the files.

Change of address. Four weeks notice is required for change of address. This should be sent to *Science*, 1515 Massachusetts Avenue, N.W., Washington 5, D. C. When ordering a change, please furnish an address stencil label from a recent issue. Address changes can be made only if the old as well as the new address is supplied.

The American Association for the Advancement of Science also publishes *The Scientific Monthly*. Subscription rates on request.

Low Temperature and Some of Its Effects Upon the Behavior of Matter

S. C. Collins

Department of Mechanical Engineering, Massachusetts Institute of Technology

SINCE THE END OF WORLD WAR II the scientific effort directed toward the properties of matter at very low temperatures has increased at a striking rate. More than a dozen laboratories in the United States are now actively engaged in researches which extend into the liquid helium range. There were only two prior to 1946.

The initial interest in very low temperatures was created chiefly by the desire to liquefy the so-called permanent gases, nitrogen, oxygen, hydrogen, helium, etc. Helium, the last to yield, was reduced to the liquid state in 1908 by Onnes. As the temperature range available for experimentation was extended to lower and lower values, it was natural to examine the physical properties of solids as well as those of the low-boiling liquids at the lower temperatures.

Properties of substances which were known to vary with the temperature were the first to receive careful study at low temperatures. Among such properties are electrical resistance, magnetic susceptibility, and specific heat. Onnes, deHaas, and others have found electrical resistance to decrease as the temperature decreases until very low temperatures are reached. At that point the resistance may assume a low constant value, the magnitude of which seems to depend upon the amount of impurity present in the specimen; it may drop abruptly to zero, in which case the substance is said to be superconducting; or it may rise sharply as the absolute zero is approached.

The magnetic properties of matter at low temperatures have been studied extensively by Gorter, Kurti, Simon, and many others. Some substances, normally paramagnetic, exhibit ferromagnetism at extremely low temperatures. Many magnetic anomalies have been observed.

Thermal agitation of molecules is sufficiently reduced at low temperatures as to make possible the observation of characteristic phenomena which are effectively masked at higher temperatures. Broad bands in the absorption spectra of some substances at room temperature appear as a number of fine lines at low temperature. The determination of crystal forms and the identification of certain groups of atoms in the molecule are sometimes possible.

With the development of the quantum theory and Nernst's heat theorem it became important to determine specific heats of solids down to the lowest possible temperature. Nernst's theorem, or the third law of thermodynamics, as it is sometimes called, may be stated as follows:

> For any reversible isothermal process which may take place in a condensed system, the change of entropy, ΔS, approaches zero as the temperature approaches zero.

Assuming Nernst's postulate to be correct, it would only be necessary to measure specific heats and latent heats of the reactants and products of a given reaction over the temperature range $T = 0$ to T in order to calculate the entropy change for the same change of state at temperature T. From the entropy change and the heat of the reaction, the equilibrium constant can be evaluated. This is of practical value, but the implication that, for all states of a system in thermal equilibrium, the entropy approaches zero as the temperature approaches zero is of the greatest theoretical importance.

Debye (*10*), recognizing the value of quantum methods for such applications, developed a theory of specific heats which is in good accord with experimental results over a very wide range of temperature. Certain marked deviations, however, have been observed, especially at very low temperatures. Investigation of the causes of such anomalies has led to significant advances in the theory of the solid state.

Giauque and his collaborators have measured the specific heat of many substances down to very low temperatures. By means of Debye's formula, the specific heat-temperature curve can be extrapolated to the absolute zero. From such measurements and calculations a value of the entropy of a substance at a chosen temperature can be determined and compared with that of the same substance determined from known equilibrium constants or by spectroscopic data. The results have helped to establish the validity of Nernst's theorem.

The preparation of suitable temperature-measuring devices for use at low temperatures has been, and still is, a time-consuming operation. The constant-volume helium gas thermometer, to which corrections are applied to secure conformity to the ideal gas scale, is acceptable all the way down to 1° K. Using this as a fundamental standard, more convenient working thermometers are usually prepared. Vapor pressure ther-

mometers are used wherever possible. The range over which they are useful is about as follows: oxygen, 90–65° K; hydrogen, 21–10° K; and helium, 4.2–1° K. Resistance thermometers of platinum, phosphor-bronze, or other metal and thermocouples are also much used.

For temperatures below 1° K reliance upon measurements of the magnetic susceptibility of paramagnetic salts is general. It is assumed that for these substances Curie's law is valid. This is $\chi = \frac{C}{T}$, where χ is the susceptibility and C is a constant. It is possible to correct this arbitrary scale to the thermodynamic scale of temperature when sufficient magnetic and heat capacity data are available.

Recent developments by Frankl (*14*) and Collins (*5*) have made practical the production of industrial oxygen by plants which require air pressures of 5–10 atm instead of 40–80 atm, which is common to older types. Frankl introduced cold accumulators and Collins a new type of reversing exchanger for the dual role of conserving refrigeration and mechanical purification of the air. Oxygen of higher purity is possible with the latter equipment.

Means for Production and Maintenance of Low Temperatures

Methods and apparatus for securing refrigeration at very low temperatures have received a large fraction of the scientific effort expended in this field up to the present time. Consequently, an account of the results of low-temperature researches of the past should describe, briefly at least, the evolution of modern techniques in low-level refrigeration.

The important physical principles used in the production of low temperatures are three in number: (1) the dependence of the internal energy of a system upon its volume as well as upon its temperature; (2) performance of external work during an expansion, when the system exerts pressure upon a moving boundary; and (3) performance of external work during demagnetization, when the system returns energy to the magnetizing agent. Nearly all actual refrigerative processes utilize a combination of principles 1 and 2.

When a body of gas is compressed adiabatically—that is, without exchange of heat with the surroundings—it becomes hot, mostly because of the work expended upon it, but also by virtue of the fact that generally the specific internal energy of a dense gas is less than that of the same gas in expanded form. If, during the compression, heat is removed so that the initial and final temperatures are equal, the amount of heat removed is the sum of the work of compression and the change in internal energy. If the gas condenses to form a liquid, the decrease in the internal energy is large in comparison to the work of compression; otherwise, it is small.

When a flask of compressed air is opened to the atmosphere and the pressure allowed to equalize, the air remaining in the flask will be quite cold, principally because of the external work performed in pushing back the atmosphere and in accelerating the fraction of the air which was ejected. This experiment was performed in 1819 by Clement and Desormes, and the cooling effect was noted. In this manner oxygen was first liquefied in 1877 by Cailletet. A cylinder of highly compressed oxygen was cooled to the lowest temperature available and then vented to the atmosphere. A mist of oxygen droplets was observed. As a means of liquefying oxygen (b.p. = 90.1° K) the method is quite ineffective. The thermal capacity of the heavy-walled cylinder is so great compared to that of the charge of gas that nearly all of the refrigerative effect is wasted. Half a century later, however, Simon (*32*), capitalizing upon the fact that at very low temperatures the specific heat of almost all metals is extremely small, revived the free expansion process for supplying both liquid hydrogen (b.p. = 20.4° K) and liquid helium (b.p. = 4.2° K). The amount of liquid which can be produced conveniently per cycle is not very large. Because of the simplicity and adaptability of the method, however, it has been extremely fruitful of low-temperature data.

To supply refrigeration continuously, a cyclic process must be substituted for the intermittent charge and discharge of the free-expansion method of cooling. The compressor then operates continuously at ambient temperatures. The compressed gas is cooled by air or water to remove the heat of compression and to effect the appropriate change in internal energy. Continuous adiabatic expansion is accomplished in one of two radically different ways. The simplest manner is to use a throttling valve in which the amount of external work consists solely of the change in the pressure-volume product of the gas. The change in temperature is relatively small. The second method consists of allowing the gas to expand against the piston of an engine in such a manner as to perform the maximum amount of external work. The maximum temperature drop for a given expansion ratio will then be secured.

Joule and Thompson first observed the change in temperature across a throttling valve in 1852. For nearly all gases the temperature falls with decreasing pressure; for hydrogen and helium at ordinary temperatures the temperature rises. At very low temperatures, however, these gases, too, produce a cooling effect by expansion.

The Joule-Thompson effect is so small that the simple expansion alone is worthless as a refrigerative process, but, used in combination with the counterflow heat

exchanger developed by Sir William Siemens about 1860, it has played a very significant role both in low-temperature research and in the production of industrial oxygen. The compressed gas, precooled to a temperature sufficiently low to insure a drop in temperature at the expansion valve, flows along one channel of the heat exchanger toward the valve and gives up heat to the slightly colder expanded gas flowing in the opposite direction along a second channel which makes good thermal contact with the first. The compressed gas arriving at the valve becomes progressively colder until the liquid phase appears. Air was liquefied in quantity by this method in 1895. Hydrogen and helium were first liquefied in this manner—hydrogen, in 1898 by Dewar, and helium, in 1908 by Onnes.

The second and more efficient type of adiabatic expansion, in which the maximum amount of external work is performed by the gas in driving an engine, was first used by Gorrie (*17*) about 1846 in the production of artificial ice. The temperature drop across such an engine can be a large fraction of the absolute temperature at the inlet, but the process is greatly improved by the addition of a counterflow heat exchanger so that the engine may be served with gas which is already quite cold. Lubrication of moving parts at very low temperatures presents a problem. Claude (*4*) produced the first successful nonlubricated expansion engine, and this had immediate commercial application in the liquefaction of air for the manufacture of industrial oxygen. The piston was sealed in the cylinder by means of a leather cup similar to that used in a tire pump. Nonlubricated expansion engines operating on compressed hydrogen at temperatures below the liquid air level were first employed about 1926 in industry for purifying hydrogen. Kapitza (*20*), in 1934, described a helium liquefier which contained, as an important element, an expansion engine in which helium was the working fluid. The compressed helium is precooled to 65° K by liquid nitrogen boiling under reduced pressure and further cooled in the heat exchanger to 20° K. A large fraction of the stream is then expanded in the engine. The cold exhaust at 10° K is used to cool further the remainder of the stream for treatment in the usual Joule-Thompson process.

Collins (*6*), supported by the Aero Medical Laboratory of the Army Air Forces, in 1946 completed a helium cryostat in which the entire interval between room temperature and 4° K is spanned without the aid of liquid nitrogen or other refrigerants. Helium is the working fluid, and the expansion ratio is relatively small (14 atm down to 1). A cold chamber in which experiments may be performed at temperatures as low as 2° K is provided. Any gas can be liquefied and transferred to external receivers. The heat exchanger and the engine are suspended in a helium atmosphere rather than in the insulating vacuum so that minor leaks can be tolerated. Twelve of these machines are now in operation in various laboratories in the United States.

The third refrigerative principle mentioned above as the decrease of the internal energy and, hence, temperature of a system during an adiabatic decrease in the magnetization of the system was suggested independently by Giauque (*15*) and Debye (*11*) in 1926. Since external work is done upon a substance when it is magnetized, there should be a rise of temperature when the process is carried out adiabatically, and a corresponding fall in temperature on demagnetization. Ordinarily the effect is very small. In the case of paramagnetic substances at very low temperatures, however, the effect is considerable, and since the specific heat of most solids is extremely small at temperatures below 2° K, a substantial drop of temperature may be expected when the magnetizing field is destroyed. In 1933 Giauque and MacDougall (*16*) attained an estimated temperature of 0.25° K upon adiabatic demagnetization of a sample of gadolinium sulfate which had been cooled to 1.5° K in a magnetic field of 8,000 gauss. Two years later deHaas and Wiersma (*19*) reached an estimated temperature of 0.0044° K. In this connection it should be noted that temperatures below 1° K are difficult to produce by the simple expedient of evaporating liquid helium at reduced pressure. The vapor pressure of helium is only 0.12 mm at 1° K, and pumps of great capacity are required to furnish appreciable refrigeration at this level.

Cooling by adiabatic demagnetization has thus opened up a temperature range not attainable by older methods. The chief deficiency of the method is the fact that the low temperature reached is a transient condition. The cold salt begins to grow warmer immediately. Serious efforts are being made to develop a method based on adiabatic demagnetization which will provide continuous refrigeration at temperatures of the order of 0.01° K.

Strange Phenomena at the Temperature of Liquid Helium

Superconductivity. The electrical resistance of a large number of metallic elements and alloys falls to zero at very low temperatures. The transition from the state of normal resistivity to the superconducting state occurs within a narrow range of temperature (less than 0.001° in the case of a single crystal of high purity). Transition temperatures for various substances range from 14.5° K for columbium nitride to 0.34° K for hafnium. An electric current, once started in a superconducting circuit, continues to flow without help from an electric cell or other source of potential.

Such permanent currents are usually started in a ring of the superconducting material by electromagnetic induction. If the temperature of the ring is allowed to rise above the transition point, the current dies out quickly because of the finite resistance.

The behavior of substances in the superconducting state is fairly complex. If a magnetic field is applied parallel to a superconducting wire, the resistance of the wire is suddenly restored at a definite field strength. The lower the temperature, the greater the field strength required to restore the resistance. The magnitude of the maximum critical field is of the order of 100–1,000 gauss. An electric current flowing through the superconducting wire will restore its resistance if the magnetic field produced by the current itself exceeds the critical value appropriate to the existing temperature. If the superconducting specimen is impure, inhomogeneous, or irregular in shape, the transition from the state of infinite conductivity to normal is not abrupt. The field strength required to produce the first trace of resistance may be a small fraction of that necessary to restore it fully.

When a superconducting cylinder of metal is placed in a magnetic field of less than the critical value, the field does not penetrate the cylinder as it would if the latter were in a normal state. This result could easily be explained on the basis of induced permanent currents set up in a thin layer on the surface of the cylinder. But if the field is established in the cylinder before it is rendered superconducting by cooling, no disturbance of the field would be expected. Meissner and Ochsenfeld (*27*) tried such an experiment and found that the lines of force had been completely expelled from the cylinder. This and subsequent experiments led to the conclusion that in a pure superconductor the magnetic induction, B, is equal to zero as long as the external magnetic field is less than the critical field strength. This condition of zero magnetic induction or perfect diamagnetism seems to be the most fundamental property of superconductors.

Currents flowing in a superconductor are generally confined to a thin surface layer. The thickness of this layer is also the depth to which an applied magnetic field penetrates into the superconductor. The penetration of the magnetic field can be expressed in terms of the number of superconducting electrons per unit volume. Different methods are available which yield some information about this quantity. Pippard (*30*) has used a radiofrequency method which measures effectively the difference between the penetration depth, λ, in the superconducting state and the skin depth, δ_n, of ordinary eddy currents when the superconducting state has been destroyed by a magnetic field. This method is applicable when δ_n does not vary with the temperature. Casimir (*3*) and Laurmann and Shoenberg (*25*) have measured the mutual inductance between two coils wound upon a superconducting core. The mutual inductance decreases slightly as the temperature is lowered because of the decrease in λ. The results have given interesting evidence of anisotropy of penetration depth in single crystals. Desirant and Shoenberg (*12*) have measured $\Delta\lambda$ from the temperature variations of susceptibility in thin cylinders. Their results indicate a value of the penetration depth at the absolute zero of 7.6×10^{-6} cm. A method similar to that of Pippard has been used by Slater and co-workers at the Massachusetts Institute of Technology, employing higher frequencies (24,000 megacycles/sec) and modern radar techniques. Their results are to be published soon.

If a small magnetic field is applied to a long superconducting cylinder in a direction perpendicular to the axis, the field strength will be doubled at the equator because of the zero-permeability of the cylinder. If the strength of the applied field exceeds one-half the value of the critical field of the specimen, then at the equator the local field strength exceeds the critical value, and superconductivity begins to disappear. The cylinder is said to pass into the intermediate state, a state of inhomogeneity in which superconducting regions and normal areas are interspersed with each other. The actual minimum field required to produce the intermediate state has been shown by Misener (*28*) and others to be approximately 0.58 H_c rather than 0.50 H_c. Landau (*22*) has explained the discrepancy on the basis of surface energy requirements at the boundaries between the normal and superconducting phases. Desirant and Shoenberg (*13*) have recently measured the magnetization of tin and mercury cylinders in transverse magnetic fields at a variety of temperatures. Their results show a sharp change in magnetization at the onset of the intermediate state and make possible an estimate of the surface energy at the boundary between normal and superconducting phases.

Impurities and irregularities in shape make the behavior of superconductors more complex. The transition temperature interval (the temperature at which resistance begins to fall rapidly minus the temperature at which the resistance completely disappears) is widened, and considerable penetration of both current and magnetic field may occur.

The most significant change in the properties of a substance during the transition from normal to superconducting state, other than the decrease in resistivity, is an anomaly in the specific heat. There is a discontinuous change in the specific heat amounting to several per cent.

When the transition occurs in zero magnetic field, there is no latent heat; but, if the change in state takes place at a lower temperature in the presence of a mag-

tic field, it is accompanied by the evolution of heat. Conversely, if the superconducting state is destroyed by increasing the field at constant temperature, heat will be absorbed. If the increase in the field strength occurs adiabatically, the temperature will fall. The transition between the normal and superconducting states is thus seen to be reversible and amenable to thermodynamic treatment. Rutgers (*31*) and Gorter and Casimir (*18*) have regarded the transition as a change in phase quite analogous to that of a vapor-liquid system and have put forward a convincing thermodynamic analysis. The transition temperature depends upon the field strength instead of on the pressure as in liquid-vapor phase equilibrium. The well-known Clausius-Claypeyron relation takes the form $\frac{dH_c}{dT} = \frac{-4\pi (S_n - S_s)}{VH_c}$ where H_c is the critical field strength and S_n, S_s denote the entropies in the normal and superconducting phases, respectively.

A satisfactory complete theory of superconductivity has not yet been advanced.

Liquid helium. The critical temperature of helium is 5.20° K, and the liquid-vapor equilibrium extends from 5.20° K to the absolute zero. Solid helium exists only under considerable pressure, 25 atm at the lowest temperatures to 5,400 atm at 42° K. There are two forms of liquid helium, helium I and helium II. The transition temperature is 2.19° K under saturation conditions and is known as the lambda point of liquid helium.

The only unusual feature of helium I is the fact that its viscosity decreases as the temperature decreases. In that respect it behaves as a gas rather than a liquid. Helium II, however, has many strange properties. Onnes observed in 1922 that, when an open Dewar vessel containing liquid helium II is surrounded by a larger Dewar vessel, the liquid quickly distributes itself between the two vessels, establishing the same level in both. If the liquid is then splashed from the inside vessel to the outside in order to make the level higher on the outside, the level outside can be seen to fall while that on the inside rises until again they are in the same plane. The liquid seemed able to flow over the retaining wall as if by a siphon.

Rollin found that the rate of evaporation of a body of helium is greatly increased when the temperature is lowered below the lambda point. He suggested that a thin layer of helium II creeps up the walls of the apparatus and is evaporated when it reaches a warmer zone. Daunt and Mendelssohn (*7*), in further experiments, were able to show that the amount of liquid transported was the same for a copper surface as for glass and was proportional to the perimeter of the surface cutting the liquid.

The thermal conductivity of helium II is phenomenally high, rising to a maximum at a point just below 2° and dropping thereafter as the temperature falls. The maximum value attained is some 200 times that of copper at ordinary temperature, 3×10^6 times that of liquid helium I. The apparent thermal conductivity strangely depends upon the temperature gradient and upon the cross-section and length of the column of liquid.

Various attempts to measure the viscosity of helium II gave rather baffling results. Wilhelm, Misener, and Clark (*35*) in 1935 obtained a value which was about one-tenth the viscosity of helium I. Allen and Misener, Kapitza, and others, using fine capillaries and flow between parallel plates, obtained widely different results. They discovered that the quantity of helium II flowing was almost independent of the pressure drop.

Allen and Jones (*1*) were the first to observe the effect upon the flow of helium II in narrow tubes of a temperature gradient in the tube. Fountains of helium rising to a height of several centimeters could be induced by allowing the light from a pocket torch to fall upon a tube packed with fine emery and partially submerged in helium II. The tube is open at both ends and equipped with a nozzle at the upper end. The flow of liquid is generally in a direction opposite to the flow of heat.

The fountain effect has been shown to be reversible. If the helium is caused to flow by mechanical means through a capillary or a tube packed with powder, a temperature gradient is set up.

To account for the extraordinary properties of helium II a number of theories have been proposed, notably by London, Tisza, and Landau. London (*26*) suggested that the transition of liquid helium might be the result of the condensation phenomenon of Bose-Einstein statistics, the condensed phase being dispersed throughout the normal phase in ordinary space but separated from it in momentum space. The atoms of the condensed phase are in the lowest energy state. The atoms of the excited phase exhibit a distribution over higher energy states as in a gas. Above the lambda point (He I) all atoms are excited. At lower temperatures (He II) the proportion of excited atoms decreases as the temperature decreases. At the absolute zero all atoms are condensed.

Accepting these ideas, Tisza (*33, 34*) has developed a theory, somewhat phenomenological in character, which has been very successful in accounting for the behavior of helium II. He pointed out that the condensation in momentum space means that helium II has a heterogeneous nature implying the existence of separate velocity fields for the two phases. This results in an "internal convection" carrying energy and entropy, but not associated with any net transfer of

matter. This complex hydrodynamics allowed the correlation of phenomena which appeared paradoxical from the point of view of ordinary hydrodynamics. The nature of the two flows is rather different.

The normal phase (excited atoms) possesses a gas-like viscosity. The viscosity of the other phase is zero—hence the name superfluid. Because of the difference in viscosity, a fine capillary becomes a semi-permeable membrane. Differences in concentration of superfluid can be created by temperature differences. If one of two vessels containing helium II and connected by a capillary is slightly warmer than the other, the concentration of superfluid within it is lower. Superfluid would flow from the second vessel into the first until a head of pressure sufficient to oppose the flow is generated. This process is analogous to osmosis in ordinary solutions. By the flow of superfluid, the fluid remaining in the colder vessel becomes warmer, while that in the warmer vessel becomes colder with admixture of the zero-point energy superfluid. The creation of a difference in temperature by causing flow through a capillary by mechanical means was predicted by Tisza (*33*) and observed by Daunt and Mendelssohn (*8*).

Assuming that the superfluid wets all surfaces to which it has access, the properties of the helium film can be qualitatively understood. The siphon effect exhibits the transport of quantities of liquid through a very thin film by virtue of the vanishingly small viscosity.

The abnormally high thermal conductivity is the result of the transport of superfluid in a direction opposite to that of the flow of heat, the superfluid being raised to the excited state, entailing the absorption of a quantity of heat which is large in relation to the quantity which might have been transferred by normal conduction or convection.

The analogy between two-phase helium and ordinary solutions is not perfect. In the case of solutions, differences in concentration are attended by diffusion, a very slow process. In the case of helium II, Tisza predicted that a concentration gradient would give rise to a current which would propagate according to a "wave equation" rather than the usual "parabolic equation" of heat conduction. The velocity of these waves was computed as a function of temperature. Later, the existence of these waves was demonstrated experimentally by Peshkov (*29*) and by Lane and his collaborators (*24*). This phenomenon, which has come to be known as "second" sound, is produced by periodic heating of helium II.

Finally, Landau's (*21*) theory should be discussed. Landau developed a complex microscopic hydrodynamics closely resembling that of Tisza. He rejects, however, the idea of any connection between helium and Bose-Einstein liquid and explains the heterogeneous nature of helium II on the basis of quantum hydrodynamics. He replaces the Bose-Einstein gas with a gas of "phonons" and "rotons."

The measurements of the velocity of "second" sound as a function of temperature by Peshkov and Lane bear out Tisza's prediction and are not in accord with Landau's equation.

Nevertheless, Tisza (*34*) has recently shown that the above-mentioned results can be obtained without any detailed molecular assumptions. Thus, the question of Bose-Einstein versus "rotons" gas theory is still open. The decision can be expected from the properties of the He^3 isotope, which obeys Fermi-Dirac statistics. These properties should show whether Bose-Einstein statistics is of fundamental importance for the phenomenon of superfluidity. Preliminary results seem to indicate that He^3 is not superfluid. Daunt, Probst, and Johnston (*9*) and Lane and Fairbank (*23*) have described new methods for the concentration of the isotope He^3. Both methods depends for their efficacy upon the isotope's failure to act as a superfluid.

The method of Daunt and collaborators consists of the transport of helium II from one reservoir to another through a thin surface film. Superfluid passes along the film easily, and normal atoms are stopped. Lane and Fairbank made use of a capillary containing helium II with a thermal gradient along the capillary. Superfluid passes from the cold end toward the warmer; normal helium, from the warmer end to the colder. In both cases substantial concentrations of He^3 were effected.

The heterogeneous nature of helium II has been demonstrated experimentally by Andronikasvilli (*2*), who measured the moment of inertia of a rotating vessel containing helium at various temperatures. The moment of inertia decreased rapidly as the temperature fell below the lambda point. The superfluid component of helium II does not take part in the rotary motion but glides through the interpenetrating atmosphere of normal helium atoms without friction—an effect first predicted by Landau.

References

1. Allen, J. F., and Jones, H. *Nature, Lond.*, 1938, **141**, 243.
2. Andronikasvilli, E. *J. Phys. USSR*, 1946, **10**, 201.
3. Casimir, H. B. G. *Physica*, 1940, **7**, 887.
4. Claude, G. *C. R. Acad. Sci., Paris*, 1902, **134**, 1568.
5. Collins, S. C. *Chem. Eng.*, 1946, **53**, 106.
6. Collins, S. C. *Rev. sci. Instr.*, 1947, **18**, 157.
7. Daunt, J. G., and Mendelssohn, K. *Nature, Lond.*, 1938, **141**, 911.
8. Daunt, J. G., and Mendelssohn, K. *Nature, Lond.*, 1939, **143**, 719.
9. Daunt, J. G., Probst, R. E., Johnston, H. L., Aldrich, L. T., and Nier, A. O. *Phys. Rev.*, 1947, **72**, 502.
10. Debye, P. *Ann. Physik*, 1912, **39**, 789.

11. DEBYE, P. *Ann. Physik*, **1926**, **81**, 1154.
12. DESIRANT, M., and SHOENBERG, D. *Nature, Lond.*, 1947, **159**, 201.
13. DESIRANT, M., and SHOENBERG, D. *Proc. roy. Soc.*, in press.
14. FRANKL, M. U. S. Patent 1,945,643 (1934).
15. GIAUQUE, W. F. *J. Amer. chem. Soc.*, 1927, **49**, 1870.
16. GIAUQUE, W. F., and MACDOUGALL, D. P. *Phys. Rev.*, 1933, **43**, 768.
17. GORRIE, J. U. S. Patent 8,080 (1851).
18. GORTER, C. J., and CASIMIR, H. *Physica*, 1934, **1**, 305.
19. DEHAAS, W. J., and WIERSMA, E. C. *Physica*, 1935, **2**, 335.
20. KAPITZA, P. *Proc. roy. Soc.*, 1934, **A147**, 189.
21. LANDAU, L. *J. Phys. USSR*, 1941, **5**, 71.
22. LANDAU, L. *J. Phys. USSR*, 1943, **7**, 99.
23. LANE, C. T., FAIRBANK, H. A., ALDRICH, L. T., and NIER, A. O. *Phys. Rev.*, 1948, **73**, 256.
24. LANE, C. T., FAIRBANK, H., SCHULTZ, H., and FAIRBANK, W. *Phys. Rev.*, 1946, **70**, 431; 1947, **71**, 600.
25. LAURMANN, E., and SHOENBERG, D. *Nature, Lond.*, 1947, **160**, 747.
26. LONDON, F. *Nature, Lond.*, 1938, **141**, 643; *Phys. Rev.*, 1938, **54**, 947.
27. MEISSNER, W., and OCHSENFELD, R. *Naturwiss.*, 1933, **21**, 787.
28. MISENER, A. D. *Proc. roy. Soc.*, 1938, **A166**, 43.
29. PESHKOV, V. *J. Phys. USSR*, 1946, **10**, 389.
30. PIPPARD, A. R. *Nature, Lond.*, 1947, **159**, 434.
31. RUTGERS, A. J. *Physica*, 1936, **3**, 999.
32. SIMON, F. *Z. Gas. Kalte Inc.*, 1927, **34**, 12.
33. TISZA, L. *Nature, Lond.*, 1938, **141**, 913; *C. R. Acad. Sci., Paris*, 1938, **207**, 1035.
34. TISZA, L. *Phys. Rev.*, 1947, **72**, 838.
35. WILHELM, J. O., MISENER, A. D., and CLARK, A. R. *Proc. roy. Soc., Lond.*, 1935, **A151**, 342.

Loyalty Clearance Procedures in Research Laboratories

Committee on Secrecy and Clearance,
Federation of American Scientists

THE POSSIBLE MILITARY APPLICATIONS of scientific research have raised several serious problems for scientists in the past few years. Of these, the problem of clearance procedures and loyalty determination has proven one of the most vexing. It has involved not only scientists working in government laboratories but also those in university, industrial, and other private laboratories.

In the belief that sufficient information on present clearance procedures has not been readily available to most scientists, this Committee was formed to survey and report on the current situation in various types of research laboratories.

Sources of Information

In November 1947 a questionnaire was sent to the directors of 140 research laboratories throughout the United States. The Committee went over lists of research laboratories operated by universities, industries, and the Federal Government and selected at random a representative number from each group. The larger laboratories in the fields of physics, chemistry, and biological sciences were favored in our selection. A letter was enclosed which described the purpose of the survey and stated that the results would be published.

Replies were received from 57 laboratories, as listed in Table 1.

Although a number of the replies were incomplete or evasive, the questionnaire yielded considerable useful information.

The committee has collected many documents, articles, and newspaper clippings pertaining to clearance procedures. A number of selected references are listed at the end of this report.

In addition, members of the Committee have corresponded or had conversations with government and laboratory officials, with about 15 scientists who have been denied clearance, and with other informed persons. We wish to thank all those whose cooperation has enabled us to collect and present this information.

TABLE 1

Type of laboratory	Questionnaires sent	Replies received	Percentage replying
Atomic Energy Commission	9	3	33
Armed Forces	25	4	16
Other government laboratories	19	10	53
Industrial and private	39	14	36
Universities	48	26	54
Total	140	57	41

This report does not attempt a complete presentation of all the data collected, but will merely summarize the salient points. The Committee hopes to publish additional detailed information in further articles. The results of the survey will be reported under the five headings named in the above table.

Atomic Energy Commission

According to the Atomic Energy Act of 1946 (*5*), no individual may be employed by the Atomic Energy Commission or have access to restricted data "until the Federal Bureau of Investigation shall have made

an investigation and report to the Commission on the character, associations, and loyalty of such individual." After receiving this report, the Commission itself has the responsibility of evaluating and interpreting the report and of deciding whether to grant or withhold clearance. It should be noted especially that the law indicates that the Commission should consider "associations" as well as "loyalty" in making this decision.

Since the Commission must rely almost entirely on the FBI to obtain facts about a given individual, there are likely to be cases where it is difficult to make a decision. These may arise from false information given to the FBI by persons who dislike the scientist concerned, from possible cases of mistaken identity, from mistaken interpretation of actions which appear questionable, or merely because the available facts put the case in the "borderline" region. It then becomes important to know what procedures the Commission has set up to safeguard loyal scientists against unnecessary clearance denial, with its attendant stigma and possible restrictions on ability to obtain another position (*2, 8, 11, 12*).

Since it took office in January 1946, the Commission has been attempting to devise procedures which would safeguard restricted data to the maximum extent and at the same time protect its employees from unfounded accusations. This task has not been simple. The interim procedures followed by the Commission have usually included some type of interview with the individual when requested. However, such issues as providing a specific detailed statement of charges and permitting cross-questioning of witnesses have yet to be resolved. In many cases the Commission and FBI feel unable to permit these for "security reasons." The accused, on the other hand, have claimed that they cannot prepare an adequate defense against unnamed charges nor against investigations which cannot be independently checked.

Furthermore, there have been made public no criteria for judging such cases beyond the words "character, associations, and loyalty." Meanwhile, a number of cases arising in various laboratories operated by the Commission have aroused widespread discussion, both at those laboratories and elsewhere. We have learned that many loyal scientists, lacking either knowledge of the criteria for clearance or confidence in the fairness of their application, have considered leaving the employ of the Commission for positions where they would be secure against unfounded accusations. Others, not now employed by the AEC, hesitate to apply for such positions for similar reasons. To the extent that this has occurred or may occur, the Nation's atomic energy research will be impaired.

These problems are especially acute in those AEC laboratories where unclassified (nonsecret) research is carried on. Our survey indicates that some type of clearance is required in these laboratories *even of scientists who have no access to restricted data.*

These provisions apply, of course, to employees of contractors and licensees of the Commission as well as to the employees of the AEC itself.

The tremendous expansion which atomic energy research is likely to undergo in the years to come, and the exclusive control held by the Commission over many aspects of nuclear research, both testify to the great importance of establishing proper precedents in this area.

In addition to injury to innocent individuals, there is another factor which has concerned various groups of scientists. They feel that the atmosphere of fear and uncertainty engendered by the occasional unfounded clearance charges may cause many scientists to withdraw entirely from any type of civic responsibility. In the field of social implications of atomic energy, in particular, it is of extreme importance that scientists continue their efforts to inform the public of all facts needed for sound policy decisions.

In order to help resolve these problems, the Atomic Energy Commission appointed, in January 1948, a "Personnel Security Review Board," headed by Owen J. Roberts, former associate justice of the U. S. Supreme Court. The other board members are Karl T. Compton, president of Massachusetts Institute of Technology; Joseph C. Grew, former Undersecretary of State; George M. Humphrey, president of the M. A. Hanna Company of Cleveland; and H. W. Prentis, Jr., president of the Armstrong Cork Company of Lancaster, Pennsylvania, and former president of the National Association of Manufacturers. At this writing the Board has not yet made public any statement of policy.

Military Laboratories

Under Public Law 808 (*5*), approved on December 17, 1942, any civil service employee of the Army, Navy, or Coast Guard may be summarily removed if the Secretary concerned considers such immediate removal "warranted by the demands of national security." Persons so dismissed are entitled to "be fully informed of the reasons for such removal" and may submit statements or affidavits in their own defense. They are not entitled to confront witnesses or to appeal a case outside the Department concerned (*17*).

According to the *New York Times* of November 21, 1947, over 75 civilian employees of the Army and Navy have been dismissed since 1942 on charges involving disloyalty. A much larger number, "under suspicion of disloyalty," were earmarked for release "for reasons of payroll cutbacks."

Scientists who have been denied Army, Navy, or Air

Force clearance have made the following assertions to this Committee:

(1) They have sometimes been unable to obtain either a statement of charges or a hearing.

(2) When charges were stated, they sometimes consisted only of membership in liberal, non-Communist groups, or similar reasons, indicating that the statement was either incomplete or insufficient. The accused were sometimes not even permitted to make a written copy of the charges.

(3) Prospective employers were told that such discharge was for loyalty reasons, although these employers had no connection with military or secret work.

(4) Laboratory officials have urged scientists to "resign" without statement of charges or a hearing, on the grounds that an appeal will be fruitless, and that, if unsuccessful, this will look bad on the man's record. The scientists consider this tantamount to pressing them to admit guilt concerning charges of which they are ignorant.

(5) Many of those refused clearance have been cleared for highly secret work during the war and do not know why they should suddenly be accused of disloyalty.

(6) Sometimes a new employee is not refused clearance, but is not permitted to start work "pending complete investigation." This indeterminate condition may last for over a year, by which time the scientist is likely to have given up and found a position elsewhere. This mechanism permits the military authorities to avoid statements of charges or hearings.

In view of the serious nature of these charges made by dismissed scientists, we were especially interested in learning from the directors of military laboratories what their official procedures are. Of all types of laboratories we surveyed, however, the military laboratories were least cooperative in replying to our questionnaire. In fact, only a few of the smaller laboratories sent in replies which were not completely evasive. It may be assumed that military officials have little interest in safeguarding their employees or employees of their contractors against unfounded charges. This may help to explain why these laboratories are having increasing difficulty in obtaining and holding scientific personnel.

Other Government Laboratories

President Truman's Executive Order 9835 of March 21, 1947—the so-called "loyalty order"—applies to all 2,000,000 employees of the executive branch of the Federal Government and hence includes the many scientists which staff research laboratories financed by the Department of Agriculture, the National Bureau of Standards, the Smithsonian Institution, the Bureau of Mines, the Food and Drug Administration, etc. In general the work of these laboratories is not secret.

It may be of interest at this point to summarize the major features of this loyalty order (*15*).

All present employees are to be investigated. Any employee charged with being disloyal is entitled to an "administrative hearing" before an agency loyalty board and has the right to appeal to the 20-member Loyalty Review Board, headed by Seth W. Richardson (*13*). However, the finding of either board is to be merely advisory; the department or agency head may dismiss an employee even if he is acquitted by such a board.

The charges shall be stated to the employee "as specifically and completely as . . . security considerations permit." The FBI or Civil Service Commission "may refuse to disclose the names of confidential informants" even to the Loyalty Review Board. The defendant, therefore, may have considerable difficulty in proving his innocence (*1, 4, 6, 7, 9, 14, 16, 18, 19*).

The standard set up for refusal of employment or removal from employment is that "on all the evidence, reasonable grounds exist for belief that the person involved is disloyal to the Government of the United States. . . . Activities and associations of an applicant or employee which may be considered in connection with the determination of disloyalty may include one or more of the following: . . . ."

After listing such standard items as treason, espionage, and sedition, the list concludes with "membership in, affiliation with or sympathetic association with" any organization designated as subversive by the Attorney General. In regard to such designation, the order does not require that this list of organizations be made public. The present Attorney General did, however, publish, on December 4, a list of about 90 groups (*3*). There is no provision for such organizations to appeal the decisions of the Attorney General.

In the case of all *applicants* for employment, an extensive investigation of loyalty is also required, but here the order fails to provide for any statement of charges or appeal.

Over $10,000,000 has been appropriated to carry on the extensive investigations required by this order.

Industrial Research Laboratories

Of the 14 leading industrial and private laboratories which answered this Committee's questionnaire, 9 do part of their research work under contract with the Army, Navy, or the AEC. Of this latter number, 8 of the contracts (57%) involve projects classified as secret. The personnel involved in this work are, of course, subject to the same clearance procedures as outlined above for the AEC and military laboratories.

An issue which has caused considerable discussion in the case of such contracts involves clearance of scientific personnel engaged solely in nonsecret research, not connected with government contracts. Certain laboratory administrators advocate requiring clearance for all their employees as a condition of employment, to permit free discussion of secret work between those actively engaged in it and their colleagues who are not. Groups of scientists have objected to this procedure, maintaining that:

(1) Under present clearance procedures, a man may be denied clearance by error or because he is considered a poor "security risk" through no fault of his own.

(2) If many laboratories adopt such a policy, the scientist's entire field of specialization may be practically closed to him, despite his desire to do no work connected with military or secret matters.

(3) It has been charged that some laboratories have used this approach to eliminate unwanted personnel.

At present this issue has not been wholly resolved. Among three leading research laboratories in the electrical industry, for example, one requires clearance for all scientific personnel, although less than half its work is secret. Another has decided to isolate its secret work and not subject its other employees to any clearance procedure. The third requires clearance of all new employees and attempts to get it for all old employees; among old employees denied clearance, some have been dismissed and some have not. The policy in that laboratory seems to be still in the formative stage.

University Research Laboratories

Replies to this Committee's questionnaire were received from 26 laboratories representing the fields of physics, chemistry, and biological sciences in the country's larger universities. Of these, 23, or 88%, do part of their research under contract with the Federal Government, mostly Army and Navy, and 11 derive over half their research funds in this manner.

Six of these laboratories (23%) indicated that part of their research involved work classified as secret and consequently required personnel security clearance by the appropriate government agency.

In this connection it may be of interest to quote from the report issued on August 27, 1947, by the President's Scientific Research Board, headed by John R. Steelman. The reports recommends: "As a matter of policy, no secret or confidential research or development projects should be placed with universities in time of peace. Every effort should be made to transfer these projects to Federal establishments."

Because the traditional freedoms of thought, expression, and research have long been cherished in universities, it is of special interest to investigate the extent to which "loyalty" and "security" problems are affecting our campuses. One question asked by this Committee concerned the attitude of the laboratory director or department chairman toward employing scientists to do nonsecret research for which they were well qualified, but who had been previously denied security clearance elsewhere. "The previous clearance refusal would not effect the likelihood of our employing him," was the answer from 16 laboratories. Four directors indicated that they would be very hesitant to hire such a person. In the case of two of these, the universities had contracts for secret work; in the other two cases, no secret work was being done in the laboratories.

Conclusions

Our investigations have shown that large numbers of scientists have become concerned over allegedly arbitrary dismissals of certain of their colleagues. Scientists who used to consider that their positions depended only on the value of their scientific work now find that their political beliefs are also being investigated, even when their research has no connection with the government. Upon examining the laws and regulations under which clearance procedures are administered, they find few safeguards against mistakes or arbitrary abuses.

The files of this Committee contain many letters from biologists, chemists, engineers, and physicists unable to learn why they are subjected to the financial loss and personal embarrassment of clearance denial. The letters often contain lengthy introspective passages on their belief in democracy and their frustration at being unable to speak in their own behalf.

It has been repeatedly emphasized by government officials that, when doubt exists as to the loyalty or even the probable future behavior of an employee, the doubt is resolved in favor of the Government. Hence, it is argued, no stigma should be attached to a person denied clearance, since it may not have been his fault at all. The dissemination of such an attitude has indeed much to recommend it.

As a practical matter, however, it seems evident that most persons do hold such a record against a man, and that his personal reputation and often his ability to obtain another position are seriously jeopardized. Therefore, every effort should be made to make clearance procedures as fair and just as possible in those fields where they are necessary and to restrict these procedures to those fields. The accomplishment of this aim will require continuing careful study and wholehearted cooperation on the part of both public officials and scientists.

It is pertinent to quote the following resolution on clearance procedure, which was passed on December

28, 1947, by the Council of the Federation of American Scientists:

"There should be separate policies for classified (secret) and unclassified research, as follows:

"Policy A, for unclassified work.

"There should be no type of 'loyalty check' either for employees or applicants for employment. If an applicant had previously been refused security clearance for classified work, this should have no effect on whether or not he is employed.

"This policy should be held by all laboratories doing no classified work, including university, industrial, and government laboratories. Laboratories engaged partly in secret work should apply this policy to their entire unclassified program, and isolate their secret work from employees who are not cleared.

"Policy B, for classified work.

"1. Although general criteria for clearance are difficult to set down precisely, we object to unreasonable criteria, such as 'guilt by association' or use of rumors not substantiated by full investigation.

"2. Procedures should ensure that if an employee or applicant for employment is refused clearance, this fact cannot be learned by the public or by future employers unless (1) such employer does classified work which requires clearance, or (2) the employee himself chooses to reveal the clearance refusal.

"3. In all challenged cases of clearance refusal there should be a hearing before a jury selected from a panel of working scientists within the area of secrecy. The employee should receive a detailed statement of the charges against him. There should be an effective means for an independent check on evidence presented at the hearing, including the right of the accused to cross-examine witnesses, and adequate provision for appeal."

References

1. AMERICAN CIVIL LIBERTIES UNION. Statement on Loyalty Tests for Federal Employment, adopted April 7, 1947. (Obtainable from ACLU, 170 Fifth Avenue, New York City.)
2. ANDREWS, B. A State Department Security Case. *New York Herald Tribune,* November 2, 1947, p. 1. (A detailed documentation of one dismissal case. Later this employee was permitted to "resign without prejudice.")
3. CLARK, T. C. Letter from U.S. Attorney General listing "subversive" organizations. *New York Herald Tribune,* December 5, 1947, p. 20.
4. COMMAGER, H. S. Who Is Loyal to America? *Harpers Magazine,* September 1947.
5. CONGRESS OF THE UNITED STATES. Act of December 17, 1942: Public Law 808, 77th Congress; Atomic Energy Act of 1946; Public Law 585, 79th Congress; Hearings on H.R. 3588 by House Committee on Post Office and Civil Service, June 3–10, 1947; H.R. 3813 of 80th Congress, passed by House of Representatives on July 15, 1947; Senate Report No. 850, dated January 30, 1948, p. 7. (Each obtainable from Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.)
6. CUSHMAN, R. E. Civil Liberties in the Atomic Age. *Ann. Amer. Acad. polit. soc. Sci.,* January 1947.
7. CUSHMAN, R. E. The President's Loyalty Purge. *Survey Graphic,* May 1947.
8. ENGEL, L. Fear in Our Laboratories. *The Nation,* January 17, 1948, p. 63. (Eight case histories of scientists from whom clearance was withheld.)
9. HASBROUCK, J. J. Edgar Hoover's Gossip Mill . . . An FCC Official Speaks Out Boldly. *The New Republic,* December 15, 1947, p. 20.
10. KILPATRICK, C. Washington Worry-go-round. *'48, The Magazine of the Year,* March 1948, p. 126. (A Washington reporter presents 8 case histories of loyalty investigations of government employees.)
11. MILLER, B. S., and BROWN, H. S. Loyalty Procedures of the A.E.C.—A Report and Recommendations. *Bull. atomic Sci.,* February 1948, **4**, 45. (Suggests that in challenged cases a hearing be held before a jury of scientists.)
12. PIKE, S. T. Witch-Hunting Then and Now. *Atlantic Monthly,* November 1947, p. 93. Partial reprint in *Bull. atomic Sci.,* January 1948, **4**, 15. (A member of the U. S. Atomic Energy Commission defends civil rights of scientists.)
13. RICHARDSON, S. W. A statement on aims and procedures by the chairman of the President's Loyalty Review Board. *New York Times,* December 28, 1947, p. 28.
14. SCHLESINGER, A. M., JR. What Is Loyalty—A Difficult Question. *New York Times Magazine,* November 2, 1947, p. 7.
15. TRUMAN, H. S. Executive Order 9835 Prescribing Procedures for the Administration of an Employees Loyalty Program in the Executive Branch of the Government. *Fed. Reg.,* March 25, 1947, p. 1935. (Obtainable from Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.
16. WECHSLER, J. A. How to Rid the Government of Communists. *Harpers Magazine,* November 1947, p. 438.
17. WHITE, S. How the Navy Decides Loyalty. *New York Herald Tribune,* December 13, 1947, p. 1. (Includes excerpts from official code for clearance procedures.)
18. WILSON, C. E., *et al. Report of the President's Committee on Civil Rights,* especially p. 49 ff. (Obtainable from Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. $1.00.)
19. ————. Let's Make It a Professional Red Hunt. (Anonymous editorial.) *Business Week,* March 29, 1947, p. 108.

The Committee of the Federation of American Scientists which has prepared this preliminary report consists of S. H. Bauer (chairman), H. A. Bethe, L. M. Brown, P. J. W. Debye, G. K. Fraenkel, A. R. Moore, P. Morrison, R. S. Rochlin, and R. R. Wilson.

Obituary

Clark Wissler
1870-1947

With the death of Clark Wissler on August 25, 1947, modern anthropology lost one of its foremost pioneers. Like others who were early in the field, he came into it after he had had training and experience in other pursuits.

He was a product of Indiana, and throughout his career he maintained close contacts with the region in which he grew up and with its people. Born in Wayne County in 1870, he went through the local elementary and secondary schools. After graduation from high school, he taught for a while in a rural school and then entered the University of Indiana, where he received the B.A. in 1897 and the A.M. two years later. His interests there were in education and in the fledgling discipline of experimental psychology. After a brief period of teaching at Ohio State University, he was appointed an assistant in psychology at Columbia University.

At Columbia he contributed to some of the important exploratory work in tests and measurements. The problems he made particularly his own had to do with the correlations between mental and physical tests—problems which led him to seek a better understanding of human growth through improved statistical and anthropometric techniques. Here he came to work with Franz Boas. Under Boas' influence, he soon added to his interest in physical anthropology what was to become a lifelong concern with cultural anthropology.

Wissler received the Ph.D. in psychology at Columbia in 1901. The following year he accepted an appointment as assistant in ethnology at the American Museum of Natural History, an institution on whose staff he remained as an active member until his retirement 38 years later—as dean of the scientific staff in latter years—and where he continued his research until his death.

The first of a long series of field trips was made to the Dakota (Sioux) Indians in 1902, and in the following year Wissler began his researches among the Blackfoot tribe, a group he revisited many times and whose culture he described and analyzed in a notable set of monographs. His reports on the material culture of the Blackfoot, on their social life and ceremonial organization, set standards for later work, since they possessed a clarity, a fullness, and a use of documentary materials which were not frequently found among ethnographic accounts of that time. Wissler's marked abilities as a field observer were enhanced by the congeniality and sympathy he had with the people whom he studied.

The data collected in the field were utilized by him in framing general considerations. A number of Wissler's earlier papers—among them, several on Primitive Art—contributed significantly to the development of anthropological theory. In that period it was necessary not only to delimit the proper scope of anthropology but to clear away notions, then widely accepted in academic as well as popular circles, that the forms and functions of human culture could be explained by the use of a few facile generalizations such as instinct or the "unity of mankind." Wissler's writings, together with those of other leading exponents of anthropology, demonstrated that an exhaustive study of the development of a number of cultures was necessary before any valid generalization concerning culture could be made. Thus, in a paper entitled "Psychological and Historical Interpretations for Culture," which appeared in this journal (1916, **43**, 193-201), Wissler wrote, ". . . the anthropological conception of culture is entirely consistent with the psychological view, for it asserts that neither mental bias nor biological attributes are of the least avail in explaining the origin of specific culture traits and that it is only when we know the specific history of a case that we can give anything like an adequate account of its origin."

The specific realm of culture history upon which Wissler himself concentrated was that of the American Indian, and especially the tribes of the Plains. His studies helped establish and refine some of the concepts which have became part of the common currency of the discipline, such as those dealing with diffusion, with the influence of the environment, and with the notion of culture area.

Wissler's capacity for synthesizing large bodies of data and for formulating general principles which had emerged from a number of individual researches is reflected in his book, *The American Indian*, a survey which has been a standard work since its publication in 1917 and the usefulness of which has not yet been supplanted. Most widely read and influential of Wissler's five other major books has been his *Man and culture* (1923), a general presentation of anthropological thought.

As museum administrator and editor of the anthropological publications of the American Museum, Clark

Wissler was in a strategic position to further research, and anthropology is indebted to him for his wise and liberal encouragement of research projects. Such milestones in anthropological analysis as the studies of the Plains Indian Sun Dance and the Plains Age-Societies were done with his participation and sponsorship. He lent his support to such varied and valuable work as the Arctic explorations of Stefansson, the ethnological investigations at Zuñi by Kroeber, the Lynds' study of Middletown, and the archeological excavations by Nelson.

From 1924 until his retirement in 1940 Wissler devoted part of his time to the Institute of Human Relations at Yale, where he was professor of anthropology. His students there found in him a kindly mentor under whose unobtrusive guidance they were encouraged to develop their fullest potentialities. But Clark Wissler's influence as an educator extended far beyond the group of graduate students at Yale, for he made an educational tool of the Museum. Through its exhibits, through the many guidebooks and pamphlets he wrote for its publications, through his administration of its facilities and staff, he spread widely the teachings which anthropology has to offer.

Just honors came to him, among them an LL.D. from Indiana, the presidencies of the anthropological and the museum associations and of the New York Academy of Sciences, a Division chairmanship in the National Research Council. These offices he fulfilled ably—a senior statesman not only among anthropologists but in the larger community of scholars and scientists as well.

The achievements of Clark Wissler make a proud record. His research contributions influenced the growth of anthropology, his administrative abilities fostered many important developments in the field, his teaching and writing brought the fruits of research to many of his fellow men.

DAVID G. MANDELBAUM

University of California

NEWS and Notes

Construction of Cornell University's new high-voltage synchrotron should be completed in about two months, according to Robert R. Wilson, director of the Laboratory of Nuclear Studies. On this week's cover Harold Bascom, technician, is shown installing one of the more than 1,000 condensers which will be used to tune the giant magnet. The synchrotron, weighing nearly 85 tons and designed to generate energies as high as 300,000,000 electron volts, is being assembled in a large concrete and brick structure adjoining the University's new Laboratory of Nuclear Studies, scheduled for completion late this spring. Funds for the machine, designed and being constructed under the direction of D. R. Corson, B. D. McDaniel, J. W. DeWire, and C. D. Swartz, of the Cornell physics staff, were provided by the Office of Naval Research.

Identical bills providing for a National Science Foundation were introduced in both the Senate (S. 2385) and House (H.R. 6007) last Thursday. These bills, which have been drafted with White House approval in mind, provide for appointment of the director of the Foundation by the President, "by and with the advice and consent of the Senate, after receiving recommendations from the Foundation." They also provide that the director shall be appointed for a 6-year term, at a salary of $15,000 per year. Leading the bipartisan group which introduced the bill into the Senate was Republican Senator H. Alexander Smith of New Jersey; Republican Representative Charles A. Wolverton of New Jersey introduced the House bill.

About People

Rene J. Dubos, of the Rockefeller Institute for Medical Research, New York City, will discuss the results of his research on tuberculosis and plans for future work at a number of educational institutions in connection with the Sigma Xi National Lectureships. Dr. Dubos will give his first lecture at Tulane University on April 8, and will then visit Louisiana State University (9), the University of Tennessee (12), the University of Kentucky (13), Indiana University (15), Wabash College (19), the University of Cincinnati (20), Ohio State University (21), Western Reserve University (22), the University of Pittsburgh (23), Pennsylvania State College (26), and Bucknell University (27).

Augustus P. West, after 27 years of service in the Federal Government, retired from his position at the National Bureau of Standards on February 29. Dr. West had spent most of his career in the Philippines, assisting in the development of natural resources of the Islands. In 1945 he joined the Bureau staff and had since been engaged in leather research.

Mildred W. S. Schram has been appointed field director of cancer control in the newly organized Division of Cancer Control, North Carolina State Board of Health. Dr. Schram's headquarters will be in Raleigh.

Harry A. Schwartz, director of research, National Malleable and Steel Castings Company, will give the Edward Williams lecture before the annual meeting of the Institute of British Foundrymen in London on June 9. Dr. Schwartz will speak on "Solved and Unsolved Problems in the Metallurgy of Blackheart Malleable." At the 1939 meeting of the Institute Dr. Schwartz was awarded the E. J. Fox Medal for his contributions to the literature on malleable iron. He is the only person not a British subject ever to receive this award.

Abraham H. Taub has been appointed research professor of applied mathematics at the University of Illinois. Dr. Taub, now on leave from the University of Washington, is at the Institute for Advanced Study. In his new position, Dr. Taub will work with EDVAC, Illinois' new electronic computer which performs mathematical problems a thousand times faster than any standard electrically operated computing machine. EDVAC, one of four of its kind in the world, is the first to be installed in the Middle West.

David E. Henderson, assistant to the general manager and chief project engineer, Indian Motorcycle Company, has been made the first Walter Clark professor of industrial engineering as well as head of the Industrial Engineering Department, North Carolina State College.

John L. Synge has been appointed to a senior professorship in the School of Theoretical Physics at the Dublin Institute for Advanced Studies. He is resigning from his present position as head of the Department of Mathematics, Carnegie Institute of Technology, as of the end of the present academic year and will take up his duties in Dublin on September 1.

Samuel Jackson Holmes was honored by the Department of Zoology, University of California, at a gathering on the occasion of his 80th birthday (March 7). Prof. Holmes, who was an active member of the Department for more than 25 years, is the author of two recent books, *Organic form and related biological problems,* published in January by the University of California Press, and *Life and morals,* just published by Macmillan.

Charles F. Bonilla, professor of chemical engineering at Johns Hopkins University, has been appointed professor in Columbia University's School of Engineering, where he will direct research and teach in the field of chemical engineering thermodynamics.

Gerald R. MacLane, at present Benjamin Peirce instructor in mathematics at Harvard University, and last year a member of the Institute for Advanced Study, has been appointed assistant professor of mathematics at the Rice Institute.

Milton E. Parker, formerly associated with the National Dairy Products Corporation and the Beatrice Foods Company, and since 1944 a private food consultant, has been named professor of food technology at Illinois Institute of Technology, where he will be in charge of the expanding food technology program of education and research in the Biology Department.

Mayo H. Soley has been named new dean of the College of Medicine and **William B. Bean** new head of the Department of Internal Medicine, University of Iowa. Dr. Soley, now professor of medicine and assistant dean at the University of California's Medical College in San Francisco, will assume his new duties on or before July 1. Dr. Bean, associate professor of medicine at the University of Cincinnati, will go to Iowa about September 1.

Nelson C. Dale, of the Department of Geology, Hamilton College, Clinton, New York, recently returned from a 6-month visit to Denmark, Sweden, France, Switzerland, Holland, and Belgium. Fossil collections for use in the Hamilton College geological laboratories and Museum of Natural Science were made on the islands of Sjaelland and Bornholm, Denmark.

Rosalie C. Hoyt, instructor in physics at the University of Rochester since 1945, has been appointed assistant professor of physics at Bryn Mawr College, effective this fall. She will resume her work in biophysics and continue with the work in nuclear physics instrumentation in which she has been engaged at Rochester.

Harry D. Huskey, authority on large-scale automatic digital computing machinery, has been appointed chief of the Machine Development Laboratory, National Bureau of Standards. He succeeds **E. W. Cannon,** who will devote full time to his duties as assistant chief of the National Applied Mathematics Laboratories.

Grants and Awards

Twenty-one universities and hospitals have been named by the National Advisory Cancer Council, National Cancer Institute, as being in great need of more facilities if they are to do desired research in the cancer field. A. C. Ivy, executive director of the Council, stated that requests amounting to more than $8,000,000 have been considered favorably. The Council has recommended that, pending approval by the Senate of the contract authorization of $8,000,000, the $2,053,000 now available in Institute funds for construction of non-Federal research facilities be utilized among the 21 institutions. These institutions, together with the sums recommended for the construction of clinical and laboratory research facilities are: University of California Medical School, Berkeley, $1,000,000; Los Angeles County Hospital, Los Angeles, California, $35,255; University of Colorado, $400,000; Yale University, $250,000; University of Chicago, $450,000; Massachusetts General Hospital, Boston, $700,000; New England Deaconess Hospital, Boston, $400,000; Tufts College Medical School, $133,522; University of Minnesota, $543,550; Washington University, St. Louis, $450,000; College of Physicians and Surgeons, New York City, $1,000,000; New York University, Bellevue Hospital, $575,000; University of Oregon Medical School, Portland, $10,000; Lankenau Hospital Research Institute, Philadelphia, $149,000; University of Pennsylvania, $56,208; University of Tennessee, Memphis, $491,584; Meharry Medical College, Nashville, $20,000; University of Utah School of

Medicine, $416,404; University of Virginia School of Medicine, $75,000; Medical College of Virginia, Richmond, $10,588; and University of Wisconsin Medical School, $975,000.

Galen B. Schubauer and **Harold K. Skramstad**, of the National Bureau of Standards, were the recent joint recipients of the Sylvanus Albert Reed Award made at the annual meeting of the Institute of Aeronautical Sciences held in New York. Drs. Schubauer and Skramstad, nationally known for their research in aerodynamics, were cited for "their contributions to the understanding of the mechanism of transition from laminar to turbulent flow."

The New York Academy of Medicine has announced the availability of $2,000 for original research on kidney diseases, under the Edward N. Gibbs Memorial Prize, during 1948. Candidates must be physicians who have been graduated at least three years and are U. S. residents. Evidence should be submitted of research already performed and of facilities to prosecute research upon the causation, pathology, and new methods for treatment of kidney diseases. Applications, with the required evidence, should be addressed prior to April 15 to: Dr. Walter W. Palmer, Chairman, Gibbs Prize Committee, Public Health Research Institute of the City of New York, William Hallock Park Laboratory, Foot of East 15th Street, New York 9, New York.

Edwin J. Cohn, chairman, Department of Physical Chemistry, Harvard Medical School, was named winner of the 1948 Theodore William Richards Medal. The formal presentation to Dr. Cohn will be made May 13 by the Northeastern Section of the American Chemical Society. Dr. Cohn is internationally known for his work in combating disease and shock through research in blood chemistry.

The American Academy of Arts and Sciences recently announced the latest recipients of the Rumford Medals. The 1945 gold medal goes to Edwin H. Land, president, Polaroid Corporation, for new applications in polarized light and photography. The 1947 medal was awarded to E. Newton Harvey, of Princeton University, for his fundamental investigations of the nature of bioluminescence or "cold light." Due to wartime restrictions placed on scientific research, the making of these awards had been delayed.

Hugh D. Miser, geologist, U. S. Geological Survey, has been elected to honorary membership in the American Association of Petroleum Geologists, an honor achieved by only 30 geologists in the history of the Association. He will be presented with a certificate in recognition of his "distinguished service to the cause of petroleum geology" at the annual meeting to be held in Denver, Colorado, on April 27.

The Washington Academy of Sciences recently presented its Awards for Scientific Achievement for 1947 to Robert D. Huntoon, of the National Bureau of Standards, and to Harry W. Wells, of the Carnegie Institution of Washington. Dr. Huntoon was cited for his distinguished service in the advancement of electronics, and Dr. Wells was honored for his work in upper-air research and organization of the world-wide network of ionosphere stations.

B. R. Burmester, of the Regional Poultry Research Laboratory, U. S. Department of Agriculture, East Lansing, Michigan, has received from the Michigan State College Chapter of Sigma Xi the 1948 Junior Award for Meritorious Research. Following presentation of the award on February 16, Dr. Burmester spoke on "Research in Avian Lymphomatosis."

George Oenslager, who was associated with the B. F. Goodrich Company, Akron, for 30 years prior to his retirement in 1942, has been awarded the first Charles Goodyear Medal of the Division of Rubber Chemistry of the American Chemical Society. The award, established this year to honor rubber chemists for outstanding achievements, goes to Dr. Oenslager for his pioneer research which led to a great reluction in price and increase in life of tires and other vulcanized rubber products. Among the developments for which he was responsible were organic accelerators, chemicals which, when added to inexpensive, low-grade rubbers, speeded up the vulcanization process. He also contributed largely to the introduction of carbon black as a reinforcing agent, thus adding to the resistance of tire treads.

Duplicates of the medal will be given to three chemists chosen by the Division to deliver Goodyear Memorial Lectures in previous years: **Lorin B. Sebrell**, Goodyear Tire and Rubber Company; **Waldo L. Semon**, B. F. Goodrich Company; and **Ira Williams**, J. M. Huber Corporation. All will receive these medals at a dinner in Chicago, April 22, during the 113th national meeting of the ACS.

Colleges and Universities

Establishment of the George Cyril Graves Lectureship has just been announced by the Physiology Department, Indiana University Medical School. The first course of lectures will be offered in the Business School Auditorium on the Bloomington Campus, May 4, 6, and 7, and the lecturer will be Philip Bard, professor of physiology and director of the Department of Physiology, The Johns Hopkins University School of Medicine. Dr. Bard, speaking on "Brain Mechanisms and Emotional Behavior in Animals," will present the following three lectures: May 4, "Subcortical Mechanisms for Expressions of Anger and Fear"; May 6, "The Suppression of Rage Reactions by the Forebrain"; May 7, "Some Neurophysiological Aspects of Sexual Behavior." All interested persons are cordially invited to attend.

The New York University College of Medicine has inaugurated a campaign to raise $250,000 for the creation of the "Wallace Laboratories" for research in pharmacology at the NYU-Bellevue Medical Center, in honor of the late George Barclay Wallace, founder of NYU's Department of Pharmacology, who died in January.

The University of Pittsburgh recently made public the merger of the Pittsburgh College of Pharmacy, long an affiliate school, with the University. With the merger the College became the University of Pittsburgh School of Pharmacy.

Northwestern University Medical School is planning a 5-day series of televised programs showing both surgical procedures and clinical demonstrations for the American Medical Association convention in Chicago, June 21–25. The managing committee, consisting of Walter Carroll, Stuart Abel, and Henry E. Wilson, Jr., all of Northwestern's medical faculty, announced that the program is the first of such magnitude using video methods in medical education at the convention level. Approximately 1,500 observers may witness a procedure simultaneously before the various small and large receiving sets to be arranged.

The television program has been planned to demonstrate not only the latest advances in clinical and surgical procedures but also common medical problems. Northwestern is scheduling television demonstrations of various obstetrical and gynecological procedures including a Caesarian section, the "blue baby" operation, early skin grafting in severe burns, gastric resection, hand surgery, and chest surgery. In addition, the video camera will reproduce a wide range of clinical material in the fields of internal medicine, orthopedics, cancer, dermatology, endocrinology, and neurology together with a demonstration concerning peripheral nerve injuries.

Summer Programs

A course in vertebrate field zoology will be offered by the Department of Zoology, University of Texas, from June 2 to July 13. This course will be taught by the camp method in the Sierra Vieja Range of Trans-Pecos, Texas, by W. Frank Blair. Field work will involve ecological surveys, collection and identification of vertebrate specimens, and application of methods of measuring vertebrate population densities, and a wide range of independent effort will be permissible. The course is open to male advanced undergraduate and graduate students in the biological sciences.

Most ecological associations characteristic of the basin and range physiography in western Texas are readily available in the region. Major communities include lechuguilla desert, creosote-bush desert, yucca-grass plains, short-grass plains, thorny brush communities, grama-grass mountain meadows, deciduous forest of mountain streams, and juniper-covered mountain slopes.

Enrollment in the first semester of the University Summer Session and payment of a special laboratory fee of $40 are required. Further information may be obtained from Prof. Blair.

Opportunities for biological work are being offered to independent investigators and graduate students by the Highlands Biological Laboratory, Highlands, North Carolina, which is holding its 18th session June 1–September 1. This summer stipends from 5 different research fellowship funds are available to biologists of southern colleges and universities, particular consideration being given to applications of talented graduate students who need financial assistance in order to study and do research at a field station. Application blanks and further details may be obtained prior to April 15 from the resident director, Prof. Thelma Howell, Wesleyan College, Macon, Georgia.

Meetings

The 58th annual meeting of the Nebraska Academy of Sciences will be held at the University of Nebraska, Lincoln, on April 30 and May 1, according to an announcement received from D. M. Pace, president of the Academy. The meeting will take the form of section sessions at which reports of original research will be presented by members and their guests.

In addition to President Pace, the current officers of the academy are: Victor E. Levine, Creighton University, vice-president; C. B. Schultz, University of Nebraska, secretary; H. L. Weaver, University of Nebraska, recording secretary; C. E. Rosenquist, University of Nebraska, treasurer; and C. E. Georgi and W. F. Weiland, University of Nebraska, and J. S. Latta, College of Medicine, University of Nebraska, councilors.

Chairmen of the sections and affiliated societies taking part in the annual meeting are as follows: Agricultural Sciences, I. L. Hathaway, University of Nebraska; Anthropology, Jesse D. Jennings, National Park Service, Omaha; Biology and Medical Sciences, D. D. Miller, University of Nebraska; Chemistry, Engineering, and Physics, Theodore Jorgensen, University of Nebraska; Earth Science, H. P. Rhoades, University of Nebraska; History of Science, T. J. Fitzpatrick, University of Nebraska; Junior Academy, Julius D. Young, Lincoln High School; Mathematics, H. M. Cox, University of Nebraska; National Council of Teachers of Mathematics, Grace McMahon, Lincoln High School; Nebraska Council of Geography Teachers, Robert Anstey, University of Nebraska; Nebraska Science Teachers Association, Allen M. Baker, Norfolk Junior College; and Social Sciences, C. M. Elliott, University of Nebraska. R. W. Darland, University of Nebraska, is program chairman for the meeting.

The Indiana Academy of Science is holding its annual spring meeting May 14–15 at the Shades State Park, Waveland, Indiana. Field trips will be made on May 15.

A Conference on Hemoglobin is to be held in Cambridge, England, June 15–18, in memory of the late Joseph Barcroft. According to F. J. W. Roughton, professor of colloid science at the University of Cambridge, the first morning will be devoted to biographical tributes, the remaining 5 sessions consisting of specialized conferences on various research aspects of hemoglobin and related subjects. It is expected that many scientists from different parts of the world will be able to attend and that papers presented at this meeting will in due course be published as a Memorial Symposium. Those interested in attending should write directly to Dr. Roughton.

A Conference on the Physics of Metals will be held in Amsterdam July 12–18 under the auspices of the Netherlands Physical Society and the Netherlands Committee of the International Union of Pure and Applied Physics. The principal topics will be: electronic phenomena in metals, ferromagnetism, and plasticity and elasticity of metals. The following speak-

ors have been invited: Richard M. Bozorth, Bell Telephone Laboratories; Sir Lawrence Bragg, Cambridge; W. G. Burgers, Delft; H. Borelius, Stockholm; C. J. Gorter, Leyden; A. Guinier, Paris; R. Kronig, Delft; N. F. Mott, Bristol; L. Néel, Grenoble; Linus Pauling, California Institute of Technology; J. L. Snoek, Eindhoven; J. H. Van Vleck, Harvard University; and Clarence Zener, University of Chicago. Requests for information and hotel reservations should be addressed to Dr. J. Van Kranendonk, Secretary of Reception Committee, Van der Waals-Laboratorium, Nieuwe Achtergracht 129, Amsterdam C, Holland.

NRC News

George B. Pegram, dean of the Graduate Faculties at Columbia University, has been named chairman of the NRC Committee on Patent Policy, succeeding the late Frederic W. Willard. Other members of the Committee are Bruce K. Brown, Conway P. Coe, Gano Dunn, Edward S. Mason, Archie M. Palmer, Lewis H. Weed, and Detlev W. Bronk, chairman of the NRC, ex officio.

The Committee is presently sponsoring a survey of the administration of the patentable results of scientific research in educational institutions and nonprofit research organizations, which is being conducted by Archie M. Palmer. The first report on the findings of the survey will be published in April under the title *Survey of university patent policies.* The report is organized in a series of analytical chapters dealing with patents and university research, the present situation and existing patent policies and procedures, practices with respect to patentable ideas and patents resulting from personal research, institutionally supported research, sponsored and cooperative research, medical patents, patent management procedures, the disposition of revenue received from patents and patent rights, and pertinent considerations in the formulation of a university patent policy.

Verbatim statements of 37 formalized patent policies are included as an appendix to the report, as well as an extensive list of source material references and a topical index. The report is obtainable from the NRC at $1.50 per copy, this charge being made to cover the cost of printing and mailing.

Deaths

Ralph H. Brown, 50, professor of geography, University of Minnesota, and editor of the *Annals of the Association of American Geographers,* died suddenly February 23 in St. Paul, Minnesota. His recent book, *Historical geography of the United States,* was published a week before his untimely death.

Alexander du Toit, consulting geologist for De Beers Consolidated Mines, South Africa, from 1927 until his retirement in 1941, died on February 24. He had been president of both the Geological and Geographical Societies of South Africa and had received citations for his scientific achievements from the United States, Great Britain, Australia, and his own country.

Leo G. Penn, 68, instructor in the theory and practice of pharmacy at the School of Pharmacy, Temple University, for more than a quarter of a century, died March 22 at his Philadelphia home.

Arthur Stewart Eve, 85, former head of McGill University's Physics Department, died March 24, at his home in Surrey, England.

The New York Zoological Society has learned of the capture, by its Belgian Congo Expedition, of Africa's rarest bird, the so-called Congo peacock, or Afropavo. The bird, whose existence was unknown 12 years ago, is the size of the familiar ring-necked pheasant, with bronzy-green-gold and brown feathers. The Expedition hopes to acquire more specimens of Afropavo from its base in Bongena, Stanleyville Province, together with the group of pangolins, hornbills, duiker antelopes, *Colobus* monkeys, and other strange captives it is now assembling in its "Zoo-in-Africa."

Correction: It has been called to our attention that the item on National Institute of Health Fellowships for training research personnel in tissue culture (*Science,* February 20, p. 185) should be clarified with respect to the following two points: (1) Eligibility for these fellowships is not limited to individuals connected with the Tissue Culture Commission but may apply to any properly qualified research worker. (2) Tissue culture research in the field of cancer is especially welcome, but the projects offered need not be limited to this area.

Make Plans for—

American Geophysical Union, 29th annual meeting, April 21–23, Washington, D. C.

American Association of Anatomists, April 21–23, Hotel Lorraine, Madison, Wisconsin.

Society for the Advancement of Education, Inc., April 24, 15 Amsterdam Avenue, New York City.

American Ceramic Society, April 25–30, Palmer House, Chicago, Illinois.

National Academy of Sciences, April 26–28, 2101 Constitution Avenue, Washington, D. C.

American Association of Petroleum Geologists, April 26–29, Shirley-Savoy Hotel, Denver, Colorado.

American Physical Society, April 29–May 1, Washington, D. C.

American Institute of Chemists, annual meeting, May 7 (changed from May 8), New York City.

Fourth International Congresses on Tropical Medicine and Malaria, May 10–18, Department of State Auditorium, Washington, D. C.

First International Poliomyelitis Conference, July 12–17, Waldorf-Astoria Hotel, New York City.

★ ★

AAAS
Centennial Celebration
Washington, D. C.
September 13–17, 1948

★ ★

Comments and Communications

Fluorescence of Solid Streptomycin Salts

It has been observed in our laboratories that streptomycin exerts a definite fluorescence in the solid state when exposed to ultraviolet radiations of wave lengths between 3,600 and 4,000 A. This fluorescence has been found to occur with commercial samples of streptomycin hydrochloride, streptomycin sulfate, streptomycin calcium chloride complex, and with a research sample of dihydrostreptomycin hydrochloride. The products of various manufacturers have been investigated, the phenomenon having been found to occur in all samples.

It is of extreme interest to note that a purified sample of streptomycin B (trihydrochloride) supplied by K. Folkers and R. L. Peck showed no fluorescence under similar conditions. This sample yielded an "assay" value of 600 μg/mg on basis of maltol assay but showed a microbial activity of only 135 μg/mg against *B. subtilis*.

The fluorescence of solid streptomycin salts is apparently quenched upon solution. Concentrated (1,000,000 μg/ml) aqueous solutions prepared from a highly purified sample of the calcium chloride complex showed negligible fluorescence. This is also true of saturated solutions in methanol. Unfortunately, no commercial apparatus is known to the undersigned for the quantitative measurement of fluorescence of solids. An instrument which we think will be adequately sensitive has been designed, and, upon its completion, measurements will be made to attempt to correlate fluorescence with microbial activity. Due to the fact that samples from diverse manufacturers and localities demonstrate this fluorescence and that it is readily noticed that high-purity samples fluoresce more strongly than low-purity material, we believe that this phenomenon is characteristic of the streptomycin moiety and is not due to the presence of trace impurities.

H. A. FREDIANI

Merck & Co., Inc., Rahway, New Jersey

Should There Be a *Living Metasequoia*?

E. D. Merrill's recent communication about a living *Metasequoia* (*Science*, February 6, p. 140) once more focuses attention upon the interrelationship of living and fossil plants and calls to mind a matter of taxonomic policy that might well receive attention in drafting appendix I of the International Botanical Rules. This appendix is to contain "regulations for determining types" and presumably may be drafted in time to submit to the Stockholm Congress, scheduled to meet in 1950.

Three genera are mentioned by Merrill that were recognized from fossils before their living representatives came to light. These are: (1) *Petrophiloides* Bowerbank (1840)—type specimen, a fossil fruit of this plant; living representative, *Platycarya* Sieb. and Zucc. (1843); (2) *Caryojuglans* Kirchheimer (1935)—type specimen, a fruit from German brown coal; living representative, *Rhamphocarya* Kuang (1941); and, of course, (3) *Metasequoia* Miki (*Jap. J. Bot.*, 1941, 11, 261), the modern species of which is probably not yet described. A fourth case, that of *Steinhauera* Presl in Sternberg (1838) versus *Sequoia* Endlicher (1847), is generally known, perhaps largely because of the publicity given it by H. Potonié in connection with his rather elaborate nomenclatural proposals prior to the Brussels Congress. The name *Sequoia* was subsequently conserved officially, but there still is no good evidence regarding the generic identity of the respective *types* of *Steinhauera* and of *Sequoia*. Nathorst (*Botaniska Notiser för År 1910*, pp. 54–56) has commented on this matter particularly and, while an argument was settled through conservation of the name *Sequoia*, there was no compelling need for an official ruling. *Steinhauera* still is an available name referring to a problematic fossil group of possibly coniferous(?) relationship. It is not now, and probably never can be, very useful because of the ambiguity of its nomenclatural type. Apparently no one has questioned the generic identity of fossil *Petrophiloides* and *Caryojuglans* with their modern representatives.

The generic similarity of the fossil and "living" *Metasequoia* is supported by both Chaney (*Ecol. Monogr.*, 1947, 17, 145) and Merrill (*Arnoldia*, 1948, 8, No. 1), but the description and illustration of the type fossil material on which the name *Metasequoia* is based are not yet available to the present writer and apparently were not widely distributed, having appeared during the recent war. The taxonomic decision as to whether remarkable new living material now being studied by Wan-Chun Cheng and H. H. Hu in China is congeneric with *Metasequoia* rests on its degree of similarity with Miki's fossil type. In comparison with any fossil type certain details must be omitted; whether these have been important or not will have to be determined largely by consideration of Miki's type species and the type specimen pertaining to it.

The writer is not concerned with the question of identity because, although some authors have believed an artificial nomenclatural boundary should be drawn between "fossil" plants and others dead not quite so long, there can be no real question that living forms in many, if not in most, instances have bona fide representation in the fossil record. To deny this is to deny the pertinence of botany to paleobotany. In any given instance the question of what constitutes adequate evidence to identify a fossil specimen with an extant group must rest with students specializing in systematic study of the plants concerned.

There is, however, a point to be made regarding the source of evidence for such critical determinations. Although in a number of instances plant structures are preserved in fossils with a perfection not exceeded in modern plants save for the details of cytology, this is not a general rule, nor can we by any stretch of imagination expect that in the distant future the exquisitely preserved fossil

examples will ever be numerous enough to give a very complete picture of all the fossil forms. Ingenuity in devising new paleobotanical techniques has enormously enlarged the potential botanical information obtainable from fossils; nevertheless, the best source of information about plants in general is from the species that can provide us with *vital* information, *i.e. the extant forms.* The functional characteristics of the fossil forms must be judged always in relation to what is known about modern representatives in the present flora. Modern plants serve as standards by means of which fossil plants are evaluated. Would it not be a wise policy to acknowledge this principle taxonomically?

Nomenclatural types are of critical importance in the application of names to plants. Identification involves assignment of a specimen to a place within a group of technical circumscription, and the oldest valid name-carrier (type) within the circle of circumscription determines the name of the group. For stability of nomenclature it is most essential that the characteristics of the name-carriers be unambiguous. In fact, the essential usefulness of a name in designating a particular group of plants often depends to a large extent on how definite a determination can be provided for its nomenclatural type (see Dayton. *Leafl. west. Bot.*, 1943, 3 (10), p. 217, re. *Steinhauera*). If, as in the instances cited by Prof. Merrill, the oldest name-carrier happens to be a fossil specimen, that name under the present Botanical Rules must be applied to the group. Although opinions differ as to what the particular requirements should be for designating a new nomenclatural type (any new group must include its type), there can be little question that implications of names attached to modern material are generally more *understandable* than those carried by fossils. The writer believes that, wherever possible, the modern type material should be given precedence, but to do this a new policy must be incorporated in the code of nomenclature.

To serve this purpose the writer suggests that the following sentence be inserted in the International Rules of Botanical Nomenclature, either as a part of Article 18 under Section 2 regarding "The Type Method," or as a part of Appendix I, "Regulations for Determining Types," yet to be proposed, or in whatever place it may seem more appropriate.

Names based on types composed of modern material always take nomenclatural precedence over names permanently attached to specimens of fossil or subfossil character.

The inclusion of such a statement would authorize a departure from priority in the few instances where fossils have received names ahead of congeneric descendants in the modern flora. In these instances it would insure that the valid name is typified by material deriving from the best source of evidence and information. If such a principle were incorporated in the Rules, it would obviate any future argument like that about *Steinhauera*; it would tend to insure the stability of names established with reference to modern material as types. Although discerning paleobotanical investigation is tending more and more to link closely related ancestral forms with those of the present flora, it is probably simpler (where evidence warrants it) to place such fossils according to names referring to modern material than it is *assuredly* to adjust modern names to fit nomenclatural types among fossils that happen to have priority.

Adoption of such a provision probably would validate automatically the names *Platycarya* and *Rhamphocarya* mentioned by Prof. Merrill—both typified by modern material. It would permit Prof. Cheng and Dr. Hu to propose a new and appropriate generic name for the modern *Metasequoia.* According to Merrill, the new group suggests *Glyptostrobus* and *Taxodium* in its vegetative characters, and its botanical alliance is scarcely with *Sequoia,* as one might infer from the name of the fossils with which it has been identified.

Appropriate or not, a name is a name; however, a full set of characteristics can be established for the modern plant in a way that is scarcely true of fossil forms. Among the Coniferales, in particular, characteristics of the frequently complex type of polyembryony are important. These could be established for the modern material, but who can determine the degree to which they apply to the fossil *Metasequoia*? There always will be matters of doubt concerning some of the features of fossils regardless of how definitely their relationships may be adjudicated. Inevitably, knowledge of modern forms is on a more certain basis and is accorded more prominence in botanical thought. If this state of affairs is given due recognition as suggested above, problems of nomenclature for both fossils and modern forms will, to some extent, be clarified.

JAMES M. SCHOPF
U. S. Geological Survey, Washington, D. C.

Brown, Mature-Fruit Color in Pepper (*Capsicum frutescens*)

In a collection of pepper material from Mexico turned over to me by the late J. N. Gilmore, one strain produced fruit which turned a deep chocolate brown at maturity instead of the normal red or yellow commonly found in this species. Later, an off-type plant with brown fruit was found in a field of the California Chili variety, and one plant with brown fruit, but otherwise typical of the variety, was found in a field of Mexican Chili. In conversations with several seedsmen I have been told that this character has been seen on a number of occasions by them in their collections. The only reference in the literature to this color of pepper fruit is made by S. M. Bukasov (*Bull. appl. Bot., Genet., Plant Breed.*, 1930, Suppl. 47, 526–529), who describes two forms which are quite widespread in Mexico and in Guatemala.

The chocolate-brown mature-fruit color in pepper is of especial interest because of the nature of the brown color and its rarity or absence in fruit generally. At the onset of ripening the color changes directly from green to brown and involves all of the wall tissue, which becomes a uniform chocolate brown throughout. A suggestion of this same phenomenon is sometimes seen in certain commercial

peppers which develop a distinct brownish color before becoming a clear red at maturity. It was suspected that this color was due to the retention of chlorophyll in the ripening fruit instead of to the partial to complete loss of chlorophyll which normally accompanies the softening, coloring, and other physiological processes of ripening. Thus, with the normal red pigments developing at maturity the combination of chlorophyll and red pigments produced the brown. To determine this, F. P. Zscheile extracted mature fruit with an acetone-hexane mixture. Upon saponification, chlorophyll in high concentration was removed, leaving a reddish-orange solution in hexane. Adsorption of this mixture on a magnesia column and development with acetone in hexane demonstrated the presence of a wide variety of carotinoids, from light yellow to dark orange in color. No other types of pigments were observed.

Preliminary data on inheritance indicate that the brown fruit color is due to a single recessive gene which inhibits the normal chlorophyll destruction at fruit maturity. In a cross with a normal red-fruited form, the F_1 had normal red fruit and the F_2 population segregated 61 red to 20 brown—a very good 3:1 ratio.

Since the action of this gene appears to be the prevention of the normal chlorophyll breakdown at maturity, it should be possible to produce a green mature-fruit color by crossing with a pepper having a yellow mature-fruit color. Such a combination might possibly have some value for prolonging the sale period of green salad peppers.

This gene is of considerable theoretical interest in providing additional material for a study which is under way of the mechanism of chlorophyll decomposition during the fruit-ripening process.

PAUL G. SMITH

Division of Truck Crops, University of California, Davis

Crystalline Synthetic Vitamin A and Neovitamin A

At a meeting of the American Chemical Society on September 15, 1947, announcement was made of the commercial synthesis of vitamin A (J. D. Cawley, C. D. Robeson, L. Weisler, E. M. Shantz, N. D. Embree, and J. G. Baxter), and evidence was presented to prove that the synthetic vitamin is identical with natural vitamin A of marine origin. It was also shown that the synthetic concentrates contain neovitamin A, the geometrical isomer of vitamin A previously isolated from fish-liver oils (C. D. Robeson and J. G. Baxter. *J. Amer. chem. Soc.*, 1947, 69, 136). Since a number of geometrical isomers of vitamin A could have been produced in the synthetic process, it is of interest that only the naturally occurring forms actually resulted. This note is concerned with the identification of the two vitamins in the concentrates and with the determination of the relative amounts of each present.

The synthetic concentrates are bright orange, viscous oils, with potencies as high as 2,400,000 U.S.P. units/gm and with extinction coefficients at 325 mμ as high as 1,250. Crystalline vitamin A was obtained from the concentrates by the method developed for crystallizing the natural vitamin (J. G. Baxter and C. D. Robeson. *J. Amer. chem. Soc.*, 1942, 64, 2411). The synthetic and natural crystals were found to be substantially identical in biological potency (3,300,000 U.S.P. units/gm), ultraviolet absorption coefficient [E(325mμ) = 1,800], and in the blue color obtained with antimony trichloride [E(620 mμ) = 4,400]. Further confirmation of the identity of the synthetic and natural vitamins was obtained by comparing the melting point and other properties of the crystalline acetate and anthraquinone-β-carboxylate esters of the synthetic vitamin with those of the corresponding esters of natural vitamin A (J. G. Baxter and C. D. Robeson. *J. Amer. chem. Soc.*, 1942, 64, 2407).

It was found that the synthetic concentrates also contain neovitamin A. This was demonstrated by crystallizing the synthetic neovitamin as the red anthraquinone-β-carboxylate ester (m.p. 133–135°) by essentially the same process as that used with natural neovitamin A (*J. Amer. chem. Soc.*, 1947, 69, 136). The vitamin A in a rich synthetic concentrate was removed as completely as possible by crystallization from ethyl formate at −70°. The neovitamin present in the noncrystallizable residue was further concentrated by selective adsorption on sodium aluminum silicate. A fraction was thus obtained containing neovitamin A and vitamin A in the proportion of 90:10. Esterification of this concentrate with anthraquinone-β-carboxyl chloride followed by crystallization from methyl acetate gave an ester identical in properties with that obtained from natural neovitamin A.

Assays of two synthetic concentrates by the maleic anhydride method (*J. Amer. chem. Soc.*, 1947, 69, 136) indicated that the proportions of vitamin A and neovitamin A present were 1.5:1 and 2:1. These ratios closely approximate those earlier reported for fish-liver oils. The similarity suggests that vitamin A either *in vivo* or *in vitro* is converted, in part, by catalytic agents into neovitamin A, and therefore that the occurrence of neovitamin A in liver oils is not necessarily indicative of any peculiar requirement of the fish for this isomer. Instead, it appears that "vitamin A," physiologically speaking, must be considered as a mixture of the two geometric isomers.

We wish to thank A. J. Chechak, F. B. Clough, C. C. Eddinger, H. M. Kascher, and Max H. Stern for valuable technical assistance, and the Spectroscopy, Biochemistry, and Custom Distillation Departments of this Company for their generous cooperation.

J. D. CAWLEY, C. D. ROBESON, L. WEISLER, E. M. SHANTZ, N. D. EMBREE, and J. G. BAXTER

Distillation Products, Inc., Rochester, New York

TECHNICAL PAPERS

Effect of Cooking on the DDT Content of Beef

R. H. CARTER, P. E. HUBANKS, and H. D. MANN
Bureau of Entomology and Plant Quarantine

LUCY M. ALEXANDER and GRACE E. SCHOPMEYER
Bureau of Human Nutrition and Home Economics, U. S. Department of Agriculture, Beltsville, Maryland

During the spring of 1946, hay containing DDT was fed to beef cattle at the Alabama Agricultural Experiment Station. At the end of the feeding period several of the animals were slaughtered and the carcasses held in freezer storage until December, when they were shipped to the Agricultural Research Center at Beltsville, Maryland. Portions of one animal were used to determine the DDT content of the meat before and after cooking. This animal had received the following ration: from January 5 to March 17, 10 lbs of concentrate (1 part of cottonseed meal plus 4 parts of corn-cob shuck meal) and 10 lbs of clover hay containing 184 ppm of DDT residue; from March 18 to April 1, 10 lbs of concentrate (as before) and 10 lbs of clover hay containing 84 ppm of DDT residue. From April 2 to May 10 the animal was on pasture and received no DDT-treated hay. It was slaughtered on May 10.

Five methods of cooking were used—roasting, broiling, pressure cooking, braising, and frying (*1*). Samples of beef to be cooked by each method were prepared in duplicate. One portion of each sample was analyzed raw, and the other portion, including the drippings, was analyzed after cooking.

A two-rib cut with a normal amount of fat was divided into two one-rib roasts, and one portion was roasted medium done (65° C) at an average oven temperature of 186° C.

A sample of loin with a normal amount of fat was divided into two steaks of about equal weight or thickness, and one steak was broiled to the rare stage (54° C).

Several pieces of round steak were boned, cut in small pieces, and then divided into three portions. Two portions were cooked well done and tender as stews, one in a pressure sauce pan and the other braised in the more usual manner.

Several additional pieces of round were ground up as hamburger, and one was molded into cakes and fried well done (76° C). In this test the cooked meat and pan drippings were analyzed separately.

Chemical analyses for organic chlorine in both the raw and the cooked meat were made by the method described by Carter (*2*) for use with this kind of material. Colorimetric determinations of the DDT in both the raw and the cooked meats were made by the method described by Schechter, *et al.* (*3*). The samples were prepared for analysis by separating the bones from the meat and fat, which were then mixed, ground, and again mixed before analysis. Each sample therefore represents meat and fat only, and the results have been calculated on that basis, without regard for the weight of the bones.

TABLE 1
DDT CONTENT OF RAW AND COOKED BEEF FROM ANIMALS FED HAY CONTAINING THIS INSECTICIDE

Method of cooking	DDT (ppm) calculated from—			
	Organic chlorine determinations		Colorimetric determinations	
	Cooked portion	Raw portion	Cooked portion	Raw portion
Roasting	30	39	19	27
Broiling	27	24	21	18
Pressure cooking	8	9	8	15
Braising	7	..	7	..
Frying	..	..	16*	24
			33†	

* Meat alone.
† Drippings.

The results of the chemical analyses, given in Table 1, indicate that the DDT in the beef was not materially decomposed or lost during the cooking.

References

1. ALEXANDER, LUCY M., and YEATMAN, FANNY W. *U. S. Dept. Agric. Leaflet 17*, 1928; *U. S. Dept. Agric. Farmers' Bull. 1908*, 1942.
2. CARTER, R. H. *Anal. Chem.*, 1947, **19**, 54.
3. SCHECHTER, M. S., POGORELSKIN, M. A., and HALLER, H. L. *Anal. Chem.*, 1947, **19**, 51–53.

Experiments on Bird Navigation[1]

DONALD R. GRIFFIN and RAYMOND J. HOCK

Department of Zoology, Cornell University

Students of bird migration have generally assumed that birds head straight toward their goal, even when flying across wide stretches of ocean or other areas devoid of landmarks. Since natural migrations do not readily lend themselves to experimental study, most of our knowledge of bird navigation has stemmed from artificial homing experiments. In such experiments birds are captured, usually at their nests, and carried to a distance before release. Many species have returned from hundreds of miles, sometimes from territory which the individual birds had almost certainly never visited before, and to the sensory physiologist these homing flights have gen-

[1] This work has been supported by a contract with the Office of Naval Research.

erally appeared to pose the same problems as natural migrations. Nevertheless, one of us concluded recently, after considering all the evidence then available (*1*), that the basic assumption of an essentially straight flight path might be incorrect. Indeed, it was possible to account for most of the recorded data by assuming (A) that birds have a well-developed topographical memory, so that, having flown over an area in migration or natural wanderings, they could thereafter orient themselves within it by means of landmarks; and (B) that, when artificially transported to unknown surroundings, they explore wide areas until they reach familiar territory.

Clearly, the critical test of this exploration hypothesis would be to trace the actual flight paths of homing birds; if they fly essentially straight toward home when released in unknown territory, the hypothesis can be discarded. Gannets (*Morus bassanus*) were selected as the best available species for this experiment, since they are large white birds, easily observed from an airplane, and since they are strictly marine and virtually never fly more than a very short distance inland. Thus, we could be sure that the 17 gannets which we released more than 100 miles from the nearest salt water were in completely unknown territory. Nine of them were followed from an airplane, the remainder being controls against the possibility that the presence of the airplane 1,500′–2,000′ above the bird would influence its homing performance. Since both groups showed roughly the same speed (average, 99 miles/day) and the same percentage of returns (63% of those released in good physical condition), it seemed clear that the airplane had no detrimental effect on their homing. Furthermore, this speed and percentage of returns was comparable to the results obtained with other wild birds (*1*).

The performance of gannets is compared, in Table 1, with other species which have been transported in sufficient numbers to equivalent distances to permit a valid comparison.

TABLE 1

Species	Returns (%)	Avg. speed (miles/day)
Herring gull (inland releases)	97	90
Swallow	67	141
Gannet	63	99
Leach's petrel	61	38
Starling	54	17
Noddy and sooty tern	52	114
Common tern (inland releases)	29	109

The gannets fall in the middle of this series with respect to speed and per cent returns; and they might well have ranked higher in per cent returns but for the fact that overland flights were quite unnatural for them. They cannot take off from land without an appreciable head wind and an open space of 100 yards or more, so that any which were forced down over land from fatigue or other causes would almost certainly be lost. This probably reduced the number of returns in comparison with the other species listed in the table.

With these considerations in mind, it is appropriate to turn to Fig. 1, which shows the actual routes flown by 9 gannets followed by us for portions of their return flight ranging from 1 to 9½ hrs and from 25 to 230 miles. It is obvious that they did not head at all directly home. On the contrary, their flight paths radiate in many directions from the release point, with a suggestion of spiraling. Five of these birds were back at their nests after the following periods of time: No. 10, 70 hrs; No. 22, 45 hrs; No. 23, 45 hrs; No. 25, 24 hrs; and No. 78, 75 hrs. The rest (Nos. 3, 8, 21, and 24) did not return; but it should be noted that No. 24 was released in poor physical condition. It is quite likely that during previous fishing trips or annual migrations these gannets had flown along the entire coastline shown in Fig. 1 (with the exception of the upper Bay of Fundy). If so, this coast would be familiar territory within which they might be expected to orient themselves by means of landmarks remembered from their previous experience.

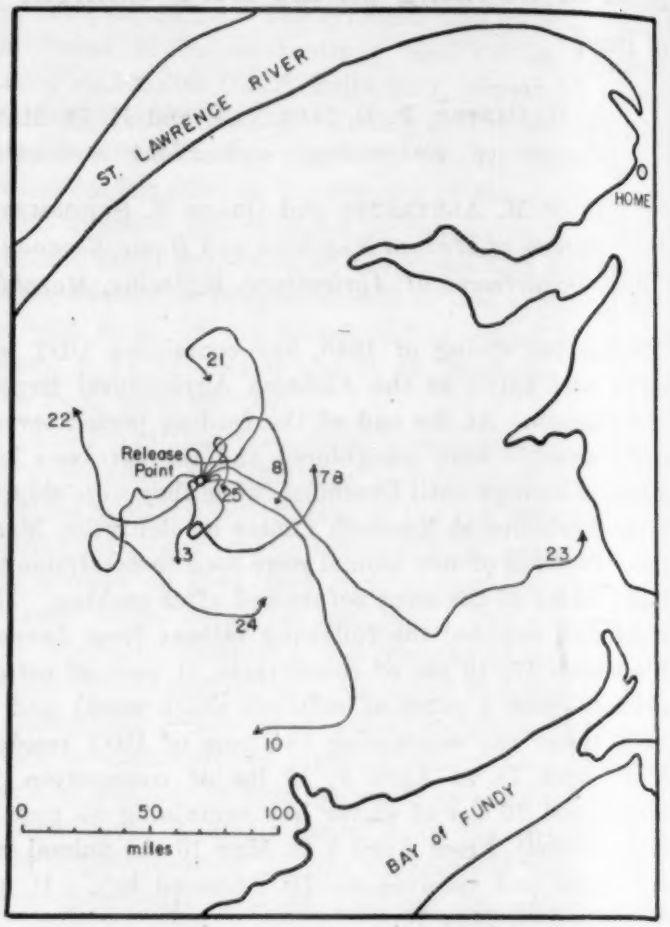


FIG. 1. Flight paths of homing gannets as observed from an airplane. The birds were captured at their nests on a small island marked "home," transported rapidly to the release point, which was in completely unknown territory, and followed as far as possible after release. The arrowhead indicates each bird's direction of flight when last seen.

A detailed description of these experiments, together with an interpretation of the results, will be presented elsewhere; but it seems clear that, for this species at least, *the actual flight paths suggest exploration rather than any absolute "sense of direction."* Since the performance of gannets is comparable to that of most other wild birds, it is quite possible that their homing ability is also based largely on exploration for visual landmarks.

What of natural migrations, particularly those which cross long stretches of ocean, or those in which young birds seem to migrate along the route characteristic of the species without adults to guide them? Clearly, one should not speculate too widely on the basis of one experiment with a single species, but it would perhaps be pertinent to re-examine the evidence concerning the directness of natural migratory flights. Could it be that transocean migrants, for example, do *not* fly straight in the absence of landmarks—or such cues as wind direction—but rely, under difficult conditions at least, on some type of exploratory searching for their goal? Since observations of the usual type tell us little or nothing about the actual flight paths of individual birds, we cannot safely infer from them that a migrant flies along an essentially straight course, although this has generally been assumed to be the case, just as it has been assumed for the return flights of homing birds.

To be sure, the important experiments of Rowan (*4*), Rüppell (*5*), and Schüz (*6*) have shown that inexperienced young birds may migrate in approximately the correct direction even without adults to guide them. These flights were over land with many landmarks available, the problem being to explain how the birds selected the appropriate cues to guide their first fall migration southward. But it seems unnecessary to conclude, as many have done (*2, 3, 7*), that birds must possess an unknown sensory mechanism capable of informing them of their latitude and longitude, or the equivalent, so that they can travel to their nest or winter range, as the case may be, without reliance on such mundane cues as landmarks, the position of the sun, or wind direction. Neither the observed flight paths of homing gannets and herring gulls nor the indirect evidence that other homing birds rely on landmarks and exploration (*1*) are consistent with these theories. Merely as an example of an alternate explanation for the results obtained by Rowan, Rüppell, and Schüz, it should be noted that the birds were released north of 50° latitude, where even in summer the sun is always perceptibly south of the zenith. Rowan's releases were made in Alberta during November, when the sun never rises more than 20° above the horizon. Thus, a tendency to fly toward the sun could perhaps account for the southward movement of these inexperienced birds.

In so far as our conclusions are relevant for other species under other conditions, they suggest that birds do not possess a special "sense of direction" or any sensitivity to the earth's magnetic field. The behavior of the gannets reinforced our impression that birds navigate by means of environmental cues which lie within the scope of the known receptors. When landmarks (rivers, coastlines, mountain ranges, etc.), prevailing winds, or the direction of the sun are not available as guiding influences, or when birds are released in unknown territory where the environmental cues have no meaning, they may well reach their goal by a process of exploration. There is need, however, for more observations from the air of the actual flight paths of other birds, both during homing flights and during migration, and one can perhaps look forward to a solution of this classic problem of biology as investigators make greater use of aircraft and other fruits of modern technical ingenuity.

References

1. Griffin, D. R. *Quart. Rev. Biol.*, 1944, **19**, 15–31.
2. Ising, G. *Arch. Math., Astron., Fys.*, 1946, **32A** (4), No. 18.
3. Mayr, E. *Bird Lore*, 1937, **39**, 5–13.
4. Rowan, W. *Trans. roy. Soc. Canad.* (3rd Ser., Sec. V), 1946, **40**, 123–135.
5. Rüppell, W. *J. Ornithol.*, 1944, **92**, 106–132.
6. Schüz, E. *Vogelzug*, 1934, **5**, 21–24.
7. Yeagley, H. L. *J. appl. Phys.*, 1947, **18**, 1035–1063.

A Mechanism of Concussion: A Theory[1]

James W. Ward, L. H. Montgomery, and Sam L. Clark

Department of Anatomy, Vanderbilt University Medical School, Nashville, Tennessee

The similarity of the forms of pressure waves generated by two entirely different methods, both of which cause cerebral concussion, has led us to formulate a theory of the physical mechanism of concussion. One method, a standard one, involves the striking of the head of an animal by a mass of known weight and velocity. In the second method, a percussion wave was set up in water in which the head of an animal was partly submerged. This procedure was employed to prevent skull distortion as much as possible. The apparatus used in these experiments was similar to that described by Clark and Ward (*2*) but produced pressure waves many times as strong. When the top of the head of a small animal (guinea pig) received a pressure wave of sufficient strength, concussion resulted as judged by certain generally accepted criteria for concussion in animals ("start reaction" with the blow, loss of corneal reflexes, temporary inhibition of respiration, etc.). The bony air sinuses of the animal's head were kept just above the surface of the water at the moment of impact in order to mitigate the effects of the pressure wave on the brain via the sinuses (*25*).

The general problem of the mechanism or mechanisms of concussion raises two prime questions. First, how do effective forces bring about the changes in function of the nervous elements in the brain to give symptoms of concussion? Second, what types of forces are capable of eliciting these changes?

With respect to the first question, several mechanisms have been postulated. These have been discussed by Denny-Brown and Russell (*4*), who discarded many of them because they are based on inadequate data. Two underlying processes associated with concussion have considerable experimental evidence supporting them: excitation and inhibition (paralysis) of the neurons of the

[1] The work described in this paper was done under a contract, recommended by the Committee on Medical Research, between the Office of Scientific Research and Development and Vanderbilt University.

brain. Emphasis has been placed on one or the other at various times, e.g., on paralysis by Denny-Brown and Russell (*4*) and on excitation followed by "physiological extinction" by Walker, Kollros, and Case (*24*). Both of these processes probably occur in concussion, as the experiments of Krems, Schopfle, and Erlanger (*16*) suggest. They conclude that "concussion would be accounted for . . . by stretch blocks of neurons plus excitation at the distorted foci, when there was evidence of excitation."

Considerable disagreement exists as to the type of force capable of causing concussion. Walker, Kollros, and Case (*24*) assume that oscillations in pressure are responsible for stimulation of neurons, but it seems exceedingly likely that the method of recording employed (Hamilton manometer) may give rise to misleading results due to the low natural frequency inherent in this system (*10*). Denny-Brown and Russell (*4*) have implicated acceleration as a basis of concussion leading to "direct traumatic paralysis of nervous function." Holbourne (*13*), however, has indicated that in a tissue with a high bulk modulus (relative incompressibility) and a low modulus of rigidity like the brain, the only type of stress likely to produce damage is a shearing one. Shearing forces develop with angular acceleration, and even in the absence of skull distortion from a blow, they would be capable of causing damage. Denny-Brown and Russell (*4*) found that a skull of a cat could be indented as much as 5 mm by a blow without causing fracture. Even less indentation of a skull of such size might lead to considerable reduction in volume with displacement of the nervous tissue toward the natural openings of the skull. This, in turn, could give rise to strong shearing displacements within the brain.

In our experiments small wire strain gages mounted on a small brass or copper cylinder (*18*) were used for recording pressures. These gages were inserted into the brain of a decapitated cat through the foramen magnum or, for the second type of experiment, were placed in the water, where they were subjected to rapid and intense pressure waves generated in it (*2*). Figs. 1 and 2 show the results obtained in these two conditions.

Considerable positive pressure lasting a few thousandths of a second was developed (200–700 lbs/in^2 or more) either in the percussion wave in water or in the head of the cat when it was struck by the falling weight. Negative pressure (tension), lasting a thousandth of a second or more, also occurred (20–75 lbs/in^2). This degree of tension appears to be possible because of the rapid development of the negative pressure and because of the viscosity and inertia of the water.

Positive pressures in the lower range (several hundred atmospheres), even though considerably prolonged, exert little effect other than a stimulation of physiological processes in living tissues. Cattell (*1*), summarizing the physiological effects of pressure, concludes that "any influence of hydrostatic pressure must be secondary to a decrease in volume." Since the coefficient of compressibility of water, the chief constituent of the brain, is 44.2×10^{-6} at 20° C in the range of 100–200 atm (*26*), it is probable that little significant change in volume is likely to occur in the ranges under consideration. Marsland and Brown (*17*) have observed only a cessation of

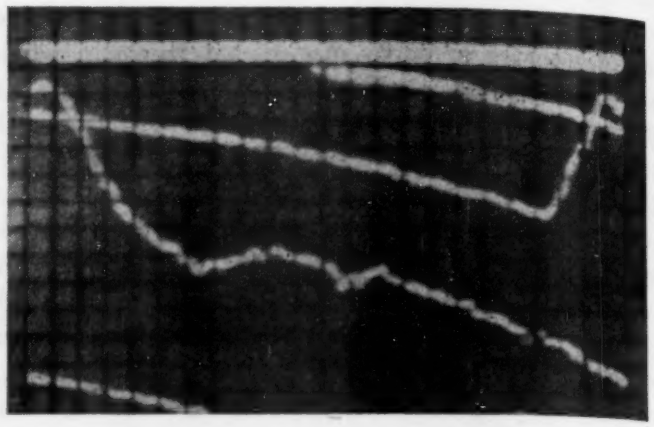


FIG. 1. Recording of a pressure wave generated within the brain of a decapitated cat when the skull was struck by a weight (937 gm) which had fallen 5′. The weight was stopped by a mechanical stop within 5 mm after impact with the skull. The surface of impact on the weight was a ball bearing ¼″ in diameter. Horizontal sweep speed of C.R.O.: 1 small square represents 1/2,760 sec. A continuous sweep was used and triggered to drop at approximately a constant rate just before the pressure wave reached a small strain gage inserted into the brain of the cat through the foramen magnum. Pressure calibration: 1 small vertical square equals 25 lbs/in^2.

The positive pressure wave lasted approximately 1/400 sec and reached 125 lbs/in^2; the negative pressure wave, about 1/700 sec and reached a value of between 15 and 20 lbs/in^2 below atmospheric pressure.

activity of *Amoeba proteus* and *A. dubia* when they are exposed suddenly to 250 atm of pressure. Regnard (*21*) found that fresh-water fish whose swim bladders had previously been emptied of air showed no effect when 100 atm of pressure was applied to them. Gaertner (*7*) ap-

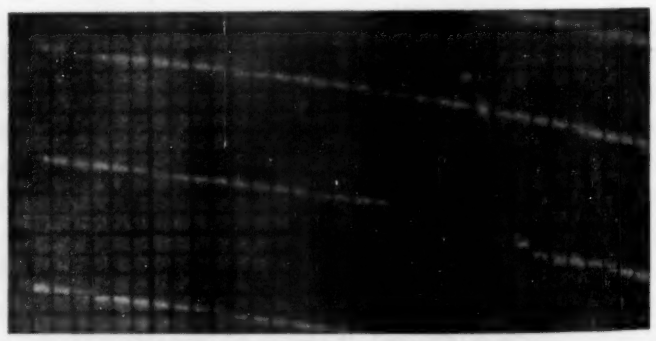


FIG. 2. Recording of a pressure wave generated in water capable of producing the symptoms of concussion in a guinea pig. A cylindrical strain gage was used in the water. Calibration: 1 small vertical square equals 100 lbs/in^2. Sweep speed: 1 small horizontal square equals 1/8,000 sec. The positive pressure wave reached a peak of about 700 lbs/in^2 and lasted 1/2,000 sec while the negative pressure wave had a value of 75–100 lbs/in^2 and lasted 1/1,000 sec.

plied 25 atm of pressure to mice and noticed no ill effects with either slow or rapid application. Grundfest and Cattell (*9*) studied nerve conduction in the sciatic nerve of the frog under the effects of hydrostatic pressure. Increase in excitability characteristics resulted from mod-

erate pressure (5,000–8,000 lbs/in²), but this was lost at higher levels (around 15,000 lbs/in²).

On the other hand, negative pressures appear to be the ready source of damage to living tissue. Johnson (*14*) found that supersonic sound waves caused the destruction of red blood cells suspended in the radiated fluid. He was able to prevent their destruction by applying a positive hydrostatic pressure of 65 lbs/in² to the entire system during radiation. This has generally been interpreted as indicating that the destruction of the cells was caused by cavitation during radiation when the system was at atmospheric pressure (*22*). It is thought that the rapid shifting of fluid which results from cavitation causes a tearing of the cells. Distortion by compression and stretching is an intermediate effect of cavitation in such a system. Harvey and Loomis (*12*), who took stroboscopic pictures of *Arbacia* eggs (diameter, 75 μ) during the course of supersonic radiation, found that specific eggs disappeared within the space of time from one picture to the next (1/1,200 sec). While in all probability this does not represent a minimum time for the formation of cavities in such a system, it indicates that the duration of negative pressure in the brain following a blow on the head or a percussion wave transmitted to the brain through water (1/700 sec and 1/1,000 sec, respectively) is sufficient to cause the formation of cavities.

Some of the available information on the mechanism of formation of bubbles within liquids in the presence of negative pressures should be considered. Harvey (*11*) has discussed the relation between "gas nuclei" and bubble formation in an analysis of decompression illness. Gas nuclei appear to be of considerable importance for the formation of bubbles in liquids where conditions are constant or changing slowly (*5, 15*). Rapidly changing conditions, however, lead readily to bubble formation (*15*) and, as Dean (*3*) has shown, the easiest method for the formation of bubbles in a solution is to introduce vortices in the fluid.

Little information is present concerning the formation of bubbles in fluids of the body under negative pressure. Harvey (*11*) has studied the effects of negative pressure just below the partial pressure of blood and with careful technic has shown that bubbles will not be formed in blood under such pressure. He found, however, that controlled muscular exercise will cause the formation of bubbles in the blood of an animal when it is placed in a pressure chamber at 110 mm Hg. He likens this observation to those resulting from the tapping of a test tube of water free of gas nuclei and immediately lowered to the same pressure. No studies are available which give direct evidence on bubble formation in body fluids at much lower pressures (below absolute zero).

Since it has not been actually possible to demonstrate transient cavities within the brain, we performed the following model experiment, not unlike one described by Harvey (*11*). Specially prepared 5% gelatin in test tubes was subjected to the rapid pressure wave in water of sufficient strength to cause concussion in guinea pigs when only the tops of their heads were subjected to the pressure wave. These tubes of gelatin were prepared by evacuating them for 30 min at an absolute pressure of 55 mm Hg during the period of cooling from 140° F to room temperature. This was done to remove trapped air on particles in the solution, and incidentally the gelatin solution was considerably degassed by the process. The right-hand tube in Fig. 3 shows that no bubbles were formed in the solidified gelatin when this tube was evacuated to 55 mm Hg. Immediately, however, bubbles appeared in another tube of gelatin (left) which had been prepared like the first, except that it had been subjected to the percussion wave in water just before being placed under the same negative pressure. When the pressure was applied only briefly to the last tube, all but the largest bubbles disappeared when the pressure was returned to atmospheric level. These experiments with the

FIG. 3. See text for description of the experiment. Both tubes were at room temperature, and the picture was taken when both were under 55 mm Hg absolute pressure.

degassed gelatin involving the rapid changes in pressure states, both positive and negative (as shown by Figs. 1 and 2), suggest strongly that transient bubbles may be formed within the fluid of the brain when such pressure waves are introduced. It is quite likely that bubble formation is even more easily accomplished in the latter situation in the face of the strong negative pressures developed because of the saturation of the fluid phase of the brain by oxygen and, particularly, carbon dioxide (*11*).

The small vibrations appearing during the negative phase of the pressure waves, as recorded in Figs. 1 and 2, probably represent indications of the development of bubbles in the brain of the decapitated cat and in the water, respectively. Further evidence for this is obtained from the following experiments: Test tubes of vacuum-pump oil (instead of water) in which a strain gage had

been placed were subjected to percussion waves in water (Fig. 4).[2] It is evident that the negative pressure wave following the positive pressure is steeper, and, proportional to the positive pressures recorded in Figs. 1 and 2, it is much greater. The explanation seems to lie in the difference in vapor pressures of the various media (and the dissolved gases?). When test tubes of water were held under a vacuum (at 27 mm Hg, absolute pressure) for as much as ½ hr, during which they were tapped repeatedly, the mercury column in the manometer dropped as much as 4 mm with each tap toward the end of this time and was accompanied by violent but brief "boiling" of the water. Upon similar treatment of the vacuum-pump oil, vigorous "boiling" also occurred, but no movement of the mercury column could be detected. (In these experiments the vacuum obtained without water in the system or with the oil present was 17 mm Hg. The pressure on the water after ½ hr evacuation and tapping was 27 mm Hg.) While it is not likely that great negative pressures (tension) would be developed in the brain following a blow to the skull, as indicated by these experiments, the production of bubbles would be relatively easy because of the partial pressure of the fluid in the brain and its dissolved gases.

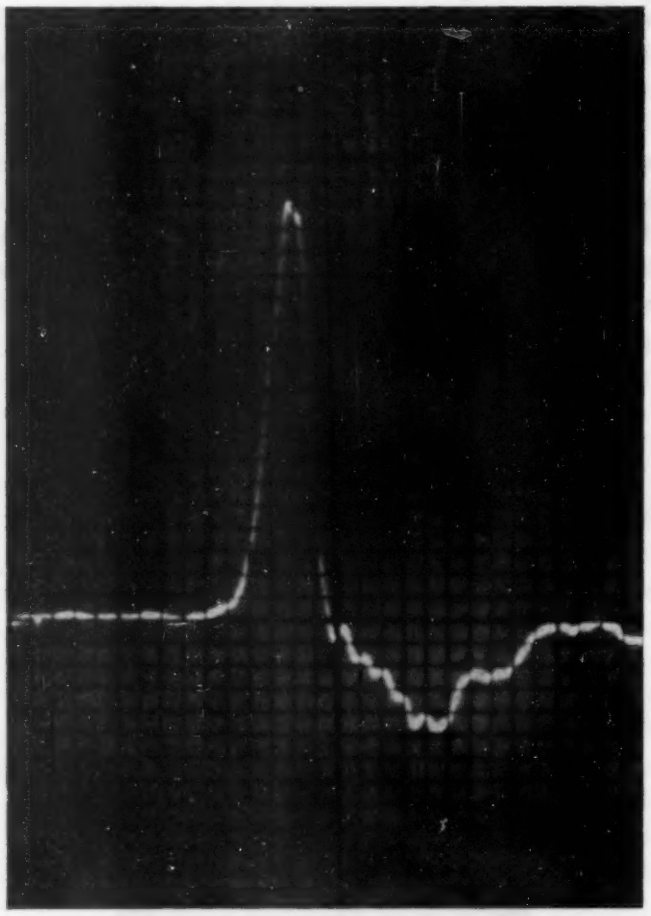


FIG. 4. The recording of a pressure wave in Cenco Hyvac oil. Calibration: 1 small scale vertical division equals 50 lbs/in². Sweep speed: 1 small scale division equals 1/10,000 sec. A positive pressure of 900 lbs was reached and lasted for 2/5,000 sec. A negative pressure of 225 lbs/in² followed and lasted about 1/1,000 sec.

The theory we would advance, then, is that damage to nervous tissue can result from a blow on the head or from the passage through it of an intense, rapid pressure wave delivered to it through water, chiefly as a result of the process of cavitation, *i.e.* "formation and vehement collapse of cavities" (*23*). This process, occurring during and following the negative phase of the pressure wave passing through the head, could lead to the production of transient local shearing forces which would affect nerve cells, fibers, synapses, and, if strong enough, even small blood vessels. These shearing forces could cause stimulation and/or blocking of nervous activity of varying degrees in various parts of the brain by distortion, depending on a number of variable factors (strength of force applied, direction of its application, rapidity of application, etc.).

These cavities may be exceedingly small, and probably are, because of the short duration of the negative pressure and of the inertia of the tissue fluids. They probably do not need to be large to cause damage, for the cavities which lead to the destruction of *Arbacia* eggs during supersonic radiation (*12*) were not visible with a magnification of approximately 25 diameters. The effect would thus be quite local. Since the number of cavities formed under such conditions may be related to the number of gas molecules in a given volume of tissue (*19*), a certain scattering of the cavities might be expected. This situation may explain the scattered distribution of chromatolytic cells which Groat, Windle, and Magoun (*8*) found in the brains of experimental animals suffering "uncomplicated concussion."

In the recording of the pressure waves in water we have seen that low-amplitude positive pressures are followed by little or no negative pressure. The theory, therefore, explains the absence of concussion when crushing forces are slowly applied to the skull (*6*). Explosive blasts, particularly in air, in the absence of the head being struck by a flying object, etc., appear to be a poor cause of uncomplicated concussion. This may be explained by the fact that, as a shock wave proceeds from its place of origin, its front becomes steeper during the time it has great energy, while the falling face of the positive pressure becomes flattened (*20*), and the factor for the production of great negative pressure is, therefore, reduced. In water, where negative pressure (tension) greater than absolute zero can occur, an explosion is likely to cause uncomplicated concussion only if the falling face of the positive pressure wave is rapid enough to be followed by considerable negative pressure, no matter how strong or how rapid the original pressure rise.

[2] This figure was reproduced in a previous article (*18*).

References

1. CATTELL, MCKEEN. *Biol. Rev.*, 1936, **11**, 441–476.
2. CLARK, SAM L., and WARD, JAMES W. *Surg. Gynec. Obstet.*, 1943, **77**, 403–412.
3. DEAN, R. B. *J. appl. Phys.*, 1944, **115**, 446–451.
4. DENNY-BROWN, D., and RUSSELL, RITCHIE. *Brain*, 1941, **64**, 93–184.
5. DIXON, HENRY H. *Roy. Dublin Soc. sci. Proc.*, 1909, **12**, 60–65.
6. FULTON, JOHN F. *New Eng. J. Med.*, 1942, **226**, 1–8.
7. GAERTNER, G. *Pflüg. Arch. ges. Physiol.*, 1920, **180**, 90–95.
8. GROAT, R. A., WINDLE, W. F., and MAGOUN, H. W. *J. Neurosurg.*, 1945, **2**, 26–35.

9. GRUNDFEST, H., and CATTELL, MCKEEN. *Amer. J. Physiol.*, 1935, **113**, 56–57.
10. HAMILTON, W. F., BREWER, GEORGE, and BROTMAN, IRVING. *Amer. J. Physiol.*, 1934, **107**, 427–435.
11. HARVEY, E. NEWTON. *The Harvey lectures.* (Ser. 40.) Lancaster, Pa.: Science Press Printing Co., 1945. Pp. 41–76.
12. HARVEY, E. NEWTON, and LOOMIS, A. L. *J. gen. Physiol.*, 1931, **15**, 147–153.
13. HOLBOURNE, A. H. S. *Lancet*, 1943, **2**, 438–441.
14. JOHNSON, C. H. *J. Physiol.*, 1929, **67**, 356–359.
15. KENRICK, F. B., WISMER, K. L., and WYATT, K. S. *J. phys. Chem.*, 1924, **28**, 1308–1315.
16. KREMS, A. D., SCHOPPLE, G. M., and ERLANGER, J. *Proc. Soc. exp. Biol. Med.*, 1942, **49**, 73–75.
17. MARSLAND, D. A., and BROWN, D. E. S. *J. cell. comp. Physiol.*, 1936, **8**, 117–178.
18. MONTGOMERY, L. H., and WARD, JAMES W. *Rev. sci. Instr.*, 1947, **18**, 289–293.
19. PICARD, JEAN. *Colloidal chemistry.* (Vol. 5.) New York: Reinhold, 1944. Pp. 1082–1093.
20. RAYLEIGH, LORD. *Proc. roy. Soc.*, 1910, **84**, 247–284.
21. REGNARD, M. P. *C. R. Soc. Biol., Paris*, 1884, **36**, 394–395.
22. RICHARDS, W. T. *Rev. mod. Phys.*, 1939, **11**, 36–64.
23. SÖLLNER, KARL. *Trans. Faraday Soc.*, 1936, **32**, 1537–1539.
24. WALKER, A. E., KOLLROS, J. J., and CASE, T. J. *J. Neurosurg.*, 1944, **1**, 102–116.
25. WARD, JAMES W., and CLARK, SAM L. *Anat. Rec.*, 1945, **91**, 305.
26. ———. *The handbook of chemistry and physics.* (14th ed.) Norwood, Mass.: Norwood Press, 1929. P. 816.

IN THE LABORATORY

Methods for Labeling Thyroxine With Radioactive Iodine[1]

EARL FRIEDEN, MORTIMER B. LIPSETT, and RICHARD J. WINZLER

Department of Biochemistry and Nutrition, University of Southern California School of Medicine

In order to study the metabolism of thyroxine it became necessary to consider the methods for labeling thyroxine with I^{131} and the positions of the radioactive iodine atoms. We wish to report on two methods that we have used to prepare radiothyroxine of high activity.

Radiothyroxine has been prepared by Horeau and Suë (*3*) from 3,5-diiodothyronine using the method of Harington and Barger (*2*), in which the iodinating agent is iodine in ammoniacal solution. It has been assumed that the compound so prepared is 3′,5′-di-I^{131},3,5,di-I^{127} thyronine. This supposition is of some importance in experiments dealing with the fate of injected thyroxine, since differences undoubtedly exist in the reactivities of the iodines of the two rings. Thus, deiodination *in vivo* may proceed preferentially at one or the other rings, and a knowledge of the position of the iodine atoms is pertinent.

The total synthesis of thyroxine by the classical method of Harington and Barger (*2*) does not offer a practical route for the preparation of the tetra-I^{131}-labeled thyroxine. This is due to the relatively short half-lives of the available iodine isotopes and an over-all yield of less than 5% in the 10-step procedure.

Labeled thyroxine has also been isolated after the injection of I^{131} into animals with functioning thyroid glands as well as after incubation of thyroid slices with I^{131} (Morton, Chaikoff, *et al.*, *5*). However, these biosynthetic methods are not practical for the preparation of radiothyroxine of high specific activity in the amounts needed for biological work. It is likely that thyroxine so prepared contains I^{131} distributed among the four positions.

A simple and convenient technique for preparing radiothyroxine was suggested by the work of Miller, *et al.* (*4*), who studied the exchange reactions of diiodotyrosine with iodine and iodide ion. They found that at pH 5 and 50° C iodine exchanged almost completely with the iodine of diiodotyrosine in 90 min.

We have similarly prepared radioactive thyroxine by an exchange reaction. In a typical experiment 5 mg of *dl*-thyroxine was introduced into 25 ml of a 9:1 butanol-water mixture at pH 5 containing 0.10 mg of I^{127} and 10 μc of I^{131} as the iodides. After being refluxed for 12 hrs, the mixture was cooled and any undissolved thyroxine removed by filtration and thoroughly washed. The remaining butanol solution was washed to remove inorganic iodide and the butanol removed *in vacuo*. The thyroxine fractions were then recrystallized from boiling 0.1 N sodium carbonate solution. In several runs, up to 30% of the radioactive iodine could be recovered in the recrystallized thyroxine. This, of course, indicates that under these conditions complete exchange was not achieved. However, with this exchange reaction, using an initial radioactivity of 10 mc of I^{131} in the solution, it should be possible to prepare 5-mg quantities of radiothyroxine with an activity of greater than 10^6 disintegrations/μg/min and thus study the metabolism of thyroxine when given at *physiological levels.*

Since we have no evidence as to whether or not all the iodine atoms in thyroxine are involved in this exchange, data obtained with this radiothyroxine may be subject to the limitation discussed above for the preparation of radiothyroxine from 3,5-diiodothyronine. The question of which iodine atoms are involved in this exchange will be difficult to solve. Previous methods employed by Har-

[1] Aided by a grant from Eli Lilly and Company.

ington (*1*) to split the diphenyl ether linkage would result in the simultaneous elimination of the iodine. A more fruitful approach would be study of the rates of exchange of the compounds 3,5-diiodothyronine and 3′,5′-diiodothyronine with I^{131}.

A convenient method of preparing thyroxine with I^{131} of identical specific activity in all four positions is through the *in vitro* iodination of certain tyrosine-containing proteins. We have prepared radiothyroxine in this way, using the procedures described by Reineke and Turner (*7*). Fifty gm of casein was iodinated using 12 gm of powdered iodine containing 10 mc of I^{131}. After hydrolysis of the iodinated casein with barium hydroxide, *dl*-thyroxine with an activity of about 10^4 disintegrations/μg/min was isolated in the usual way.

Another possible method of labeling all iodine atoms in thyroxine is the direct *in vitro* conversion of diiodotyrosine to thyroxine, as first reported by von Mutzenbecher (*6*). The low yields of thyroxine obtained make this method less desirable for the preparation of radiothyroxine than the other methods discussed.

The ease of preparation of radiothyroxine of high specific activity should facilitate further research into the metabolism of thyroxine administered at physiological levels.

References

1. Harington, C. R. *Biochem. J.*, 1926, **20**, 300.
2. Harington, C. R., and Barger, G. *Biochem. J.*, 1927, **21**, 169.
3. Horeau, A., and Sué, P. *Bull. Soc. Chim. biol.*, 1945, **27**, 483.
4. Miller, W. H., Anderson, G. W., Madison, R. K., and Salley, D. J. *Science*, 1944, **100**, 340.
5. Morton, M. E., *et al. J. biol. Chem.*, 1943, **147**, 757; Morton, M. E., and Chaikoff, J. L. *J. biol. Chem.*, 1943, **147**, 1.
6. von Mutzenbecher, P. *Z. physiol. Chem.*, 1939, **261**, 253.
7. Reineke, E. P., and Turner, C. W. *J. biol. Chem.*, 1943, **149**, 555.

A Convenient Plant Pollinating Kit

C. A. Schroeder

Division of Subtropical Horticulture, University of California, Los Angeles

During a series of hand-pollination experiments on the cherimoya considerable inconvenience and loss of time were experienced in preparing plant tags, transferring pollen, and entering field data in the notebook while using ordinary equipment. When large numbers of detailed, individually marked pollinations were made, considerable lost motion and time resulted from reaching into the shirt or trouser pocket for tags and pencil, picking up the pencil, which was dropped occasionally, transferring the pollen vials from pocket to hand, and finding some place to rest the field notebook while other operations were under way. Such losses were greatly accentuated when working on a ladder high in a tree. It was found very convenient to have all necessary "bookkeeping" equipment and other important experimental materials available and securely attached to a portable shelf or kit suspended by a cord around the neck.

The kit (Fig. 1) consists of a breastboard 6″ × 8″ and a shelf 6″ × 6″ made of ¼″ plywood. The breastboard provides stability for the apparatus and prevents twisting and

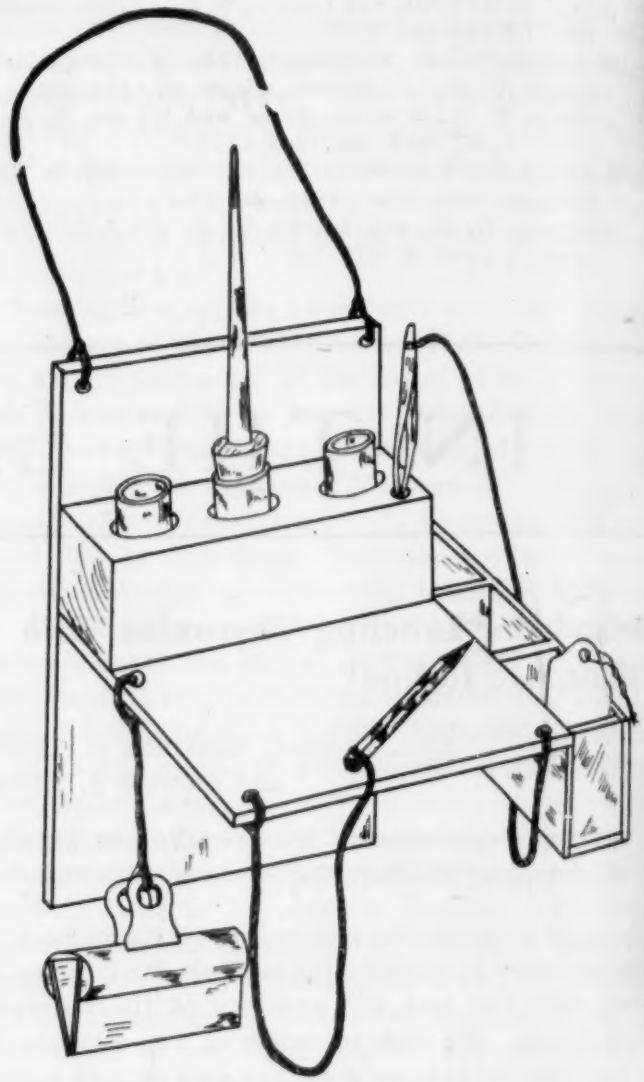


Fig. 1

fouling when working among tree branches. The shelf functions as a small desk so that a convenient and smooth writing surface is available at all times. A small block 1½″ × 1½″ × 6″ has holes drilled to receive small vials of pollen. A series of small wooden pockets are attached to one side of the desk to hold paper or wooden plant tags. Small holes drilled at the desk corners provide for attachment of a pencil, forceps, and a large spring clip from which the field notebook is suspended. The brush used for pollination work is mounted in a cork and kept in one of the pollen vials.

The compactness and convenience of the kit is self-evident. All items except the plant tags and brush are secured to the desk and cannot be dropped. When suspended from a cord passed around the neck, the kit is always in a vertical position and immediately in front of the operator in whatever position he may be. It also allows the worker's hands to be free at all times between operations.

It is thought that the basic idea may be of interest to those who have to make detailed recordings of specific pollination or other similar operations in the field.